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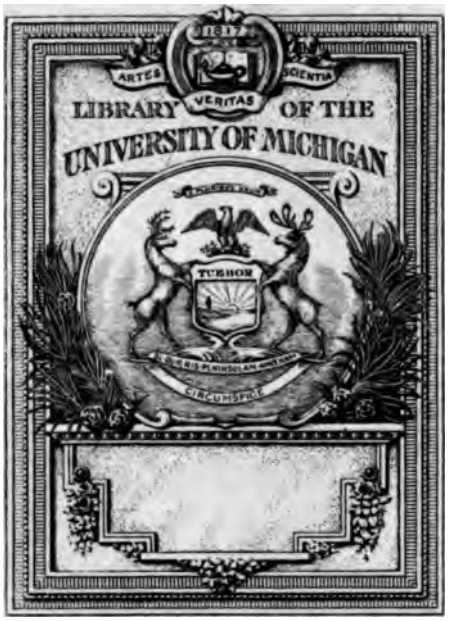
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ATTIDÆ OF NORTH AMERICA.

BY

GEORGE W. AND ELIZABETH G. PECKHAM.

INTRODUCTION.

On account of the habits of the Attidæ they are, in comparison with other families, poorly represented in collections. The most important contribution to the knowledge of North American species is the work of N. M. Hentz, his studies having been largely carried on in the southern states. The papers of Hentz were originally published in the Journal of the Boston Society of Natural History, from 1842-45, but are found in more convenient form in the collection made by Burgess in 1875. The works of Baron Walckenaer, 1837-47, and that part of Die Arachniden, by C. Koch, published in 1846, contain discriptions of many American Attidæ, but owing to the vagueness of the descriptions comparatively few can be identified with certainty. So far as Koch is concerned this is of slight importance, as his work was preceeded by that of Hentz. But with Walckenaer the question of priority comes up, as doubtless many of the species commonly ascribed to Hentz were first published by him, and he should be credited with all such species as can be identified from his descriptions. The important question is, what species can be identified by Walckenaer's descriptions?

We have made a very careful study of the descriptions of Walckenaer's sixty-four species, comparing them with nearly all Hentz's species and with many others from different sources and we have been able to identify only four.

On the subject of priority we agree with Dr. Thorell that "to reject a name, as some have proposed to do, on account of *defectiveness* in the definition, would seem not to be right, as leaving room for much arbitrariness. What seems to one good enough may to another appear insufficient or faulty. *When one only knows with certainty what is to be understood by such a name*, every one can either alter or improve the characterization for himself.[1]" We wish it to be understood that we reject none of Walckenaer's species on account of defectiveness of definition. We accept them whenever we are able to identify them.

Walckenaer's work on North American species was largely based on the manuscript plates of Abbot. He does not, so far as we know, state expressly that he has seen any of the specimens, but that he has examined most of them must be understood from the following statement which he makes before enumerating thirteen species. "Les espéces suivantes n'out pas été observées par nous, et ne sont placeés dans cette section que sur les indications fournies par les figures de l'ovurage MSS. d'Abbot, intitulé: Georgian Spiders."

[1] On European Spiders, I., p. 5. The italics in the concluding sentence are ours.

Had Walckenaer published Abbot's plates in connection with his descriptions it would doubtless have been easy to identify many of his species, but as the law of priority deals only with published matter, his claim to species must rest upon his descriptions alone, although Abbot's manuscript plates may be seen in the British Museum. In the event of their publication at some future time, such species as are identifiable, for the first time, through the figures, must be ascribed to Abbot at that date, and not to Walckenaer.

A good example of the difficulties of dealing with Walckenaer may be found in a species which he published in his first volume as *Attus protervus*, a black spider with black legs and palpi. In his fourth volume he refers to this species, saying: "Add to the synonymy *Plexippus undatus* Koch." Now there is no doubt that this last mentioned spider is identical with *Attus vittatus* (♂) Hentz, one of our most common species. The description and figure of Koch represent it fairly well as a dark spider with chevrons of white hair, and *yellow legs and palpi.* As a matter of fact the general appearance is very seldom so dark as would appear from Koch, who seems to have described from a single specimen. If, indeed, Walckenaer's *A. protervus* and Koch's *Pl. undatus* are identical, Walckenaer's description is absolutely false and bears no resemblance to the species. We can only suppose that Walckenaer was mistaken in thinking them identical.

We have callections from various parts of North America. Those of Count Keyserling (containing a number of type-specimens) and of Mr. Nicolas G. Pike have been of especial use to us. We are also indebted for specimens to the following persons. The locality in which each collection was made is indicated after the name of the sender.

Miss Edith Gifford, Mexico; Mr. Chas. Mann, Louisiana, Florida; Mr. Fr. Rauterberg, Texas; Miss Augusta Tovell, Texas; Mr. Thos. Gentry, North Carolina, South Carolina, Georgia; Mr. F. S. Risley, Florida; Col. J. J. Young, Pennsylvania; Mr. Philip Nell (for many specimens), Pennsylvania; Mrs. Mary B. Putnam, Iowa, Utah; Mr. Aurelius Todd, Oregon; Miss Murray, California; Mr. L. E. Ricksecker, California; Prof. J. J. Rivers, California; Mr. W. G. Harford, California, Washington Territory; Mr. W. G. Wright, California; Prof. O. B. Johnson, Washington Territory; Dr. F. Brendel, Illinois; Mr. Philip Abbot, Massachusetts; Mr. H. Van Rensselaer, Connecticut; J. B. Tyrrell, Esq. (Geol. Survey of Canada), Canada, Rocky Mountains; Rev. H. C. McCook, various parts of United States; M. E. Simon, Mexico; Dr. Ferdinand Karsch, collection of Attidæ of Royal Museum of Berlin (containing many North American specimens.)

North American Attidæ have been described by the following writers:

WALCKENAER: Hist. Nat. des Insectes Aptères, 1837?–47.

N. M. HENTZ: Occasional Papers, 1842–45.

C. KOCH: Die Arachniden, 1846.

GIEBEL: Illinois Spiders, Zeitschrift fur Gesammten Naturwissenschaften, 1869.

J. BLACKWALL: Spiders from Canada, Ann. & Mag. of Nat. Hist.

T. THORELL: Spiders of Colorado, Bull. of Hayden's U. S. Survey of the Territories.

E. KEYSERLING: Neue Spinnen aus Amerika, VI.

H. C. MCCOOK: Proc. Acad. Nat. Sci. of Philadelphia, 1883.

PECKHAM: Descr. new or little known Attidæ, 1883.

The Attidæ have usually a high cephalothorax with almost vertical sides, and short and thick extremities, although there are many exceptions. Perhaps the position and relative size of the eyes — in which they most nearly approach the Lycosidæ — is of most value in defining the family. The eyes are arranged in three or four transverse rows, three in the sub-family Attinæ and four in the sub-family Lyssomanæ. In the former the first row is composed of four eyes, the middle ones being the largest; the second row is composed of two very small eyes, and the third of two of medium size. In the Lyssomanae, the two outer eyes of the first row are placed so far back as to divide it into two transverse rows; otherwise the eyes are alike. The spiders are, many of them, very brilliantly colored — as much so as are the humming birds or beetles. As the markings are commonly formed of colored hairs or scales, they change considerably when the spider is wet, and are moreover, very easily rubbed off. The entire appearance of a spider may thus be changed, and its identification rendered difficult, if not impossible. The Attidæ, like the birds, moult frequently, and at each moult the markings may change, so that some of the older writers have formed several species for the different moults of one. These difficulties are increased by the fact that the adult males and females of a species usually differ considerably in appearance.

Although a great many species have been described, we have been able to identify but a limited number. The Attidæ live on the ground, on plants, and on trees, jumping on their prey. They form no web, but generally attach a line when they jump, to save themselve in case they miss their aim. The females place the cocoon under leaves or bark and spin some cross lines, under which they stand until the eggs are hatched.

Of the fifty-five species described by Hentz, we have identified forty-five. Of the ten remaining, probably five or six are varieties of those that we have described, but this being uncertain, we have not included them.

The key which follows is useful only in determining the species described in this paper:

KEY TO GENERA OF NORTH AMERICAN ATTIDÆ.

1. Eyes in four rows ..... LYSSOMANES.
2. Eyes in three rows 3
3. Body slender, ant-like, legs weak 5
4. Body not slender nor ant-like 9
5. Cephalic part higher than thoracic: lip much longer than wide SALTICUS.
6. Cephalic part not higher than thoracic: lip as wide as long 7

7. Thoracic part divided by a marked constriction into a shorter anterior and a longer posterior portion; quadrangle of eyes wider than long.....SYNEMOSYNA.
8. Thoracic part not divided; quadrangle of eyes much longer than wide.....SYNAGELES.
9. Cephalic part at least as long as thoracic[1]..... 11
10. Cephalic part shorter than thoracic..... 21
11. Cephalic part occupying $\frac{3}{4}$ of the cephalothorax.....[2]HOMALATTUS.
12. Cephalic part occupying plainly less than $\frac{3}{4}$ of cephalothorax..... 13
13. Spiders very small — not so much as 3 mm. long..... 15
14. Spiders[3] not very small 17
15. Quadrangle of eyes equally wide in front and behind, legs 4, 3, 1, 2 [4]NEON.
16. Quadrangle of eyes wider behind, legs 4, 1, $\overline{2, 3}$.....BALLUS.
17. Quadrangle of eyes equally wide in front and behind; first row strongly curved; cephalothorax very convex, with cephalic part strongly inclined forward, and falling steeply behind...AGOBARDUS.
18. Quadrangle of eyes wider behind; first row straight or very slightly curved; shape of cephalothorax unlike the above..... 19
19. Cephalothorax high, nearly as wide as long; dorsal eyes at widest point of cephalothorax, opposite a corner, and projecting; quadrangle of eyes, looked at from above, seeming to occupy $\frac{4}{5}$ of cephalothorax.....ZYGOBALLUS.
20. Unlike the above.....ERIS.
21. Quadrangle of eyes wider in front..... 23
22. Quandrangle of eyes wider behind, or equally wide in front and behind..... 27
23. First row of eyes straight; patella + tibia III shorter than patella + tibia IV .....ASTIA.
24. First row of eyes curved; patella + tibia III equal to patella + tibia IV..... 25
25. Dorsal eyes nearer to each other than to lateral borders; legs (♂) 1, 3, 4, 2; (♀) 4, 3, 1, 2.....PROSTHECLINA.
26. Dorsal eyes further from each other than from lateral borders; legs (♂ ♀) $\overline{4, 3}$, $\overline{1, 2}$.....[5]SAITIS.

---

[1] The cephalic part extends from the anterior margin of the lateral eyes of the first row to the posterior margin of the eyes of the third row.

[2] The only North American species of this genus yet known has metallic reflections, and when the spider is looked at from above the cephalic part seems to occupy nearly the whole cephalothorax.

[3] *Zygoballus sexpunctatus* H. is only 3 mm. long, but is distinguished from *Neon* and *Ballus* by its peculiar falces, as well as by the shape, and greater height of its cephalothorax.

[4] In *Neon* the dorsal eye is plainly larger than the anterior lateral.

[5] In *Saitis* legs III and IV are much longer than I and II, while in *Prostheclina* the difference is not so marked.

27. [1]Cephatolthorax high, massive; quadrangle of eyes plainly wider (often much wider) behind; first row of eyes usually curved; legs 1, 4, 3, 2, 1, 4, 2, 3, 4, 1, 3, 2, or 4, 3, 1, 2..... 29
28. Unlike the above..... 33
29. Legs 1, 4, 3, 2, 1, 4, 2, 3 or 4, 1, 3, 2..... 31
30. Legs 4, 3, 1, 2.....PLEXIPPUS.
31. Eyes of second row twice as far from dorsal as from lateral eyes. PHIDIPPUS.
32. Eyes of second row halfway or about halfway between lateral and dorsal eyes.....PHILÆUS.
33. Third leg longest, fourth next.....HABROCESTUM.
34. Unlike above..... 35
35. Cephalothorax convex, and high, or moderately high..... 51
36. Cephalothorax low and flat..... 37
37. Abdomen at least four times as long as wide; cephalothorax low and flat, not wider than third row of eyes; legs of first pair very long.....HYCTIA.
38. Unlike the above..... 39
38. Spines only on metatarsi of first pair.....[2]ADMESTINA.
40. Legs all spined..... 41
41. Cephalothorax plainly wider than third row of eyes, quadrangle equally wide in front and behind..... 43
42. Unlike the above..... 45
43. Quadrangle of eyes $\frac{1}{4}$ wider than long, occupying $\frac{2}{5}$ of cephalothorax; lateral eyes of first row separated by not more than $\frac{1}{3}$ their own diameter from middle eyes.....MENEMERUS.
44. Quadrangle of eyes $\frac{1}{3}$ wider than long, occupying $\frac{1}{3}$ of cephalothorax; lateral eyes of first row separated by at least $\frac{1}{2}$ their own diameter from middle eyes.....MARPTUSA.
45. Middle eyes of first row three times as large as lateral eyes; quadrangle of eyes nearly twice as wide as long.....[3]SADALA.
46. Middle eyes of first row about twice as large as lateral eyes; quadrangle of eyes not more than $\frac{1}{3}$ wider than long..... 47
47. Metatarsi III and IV with spines only in terminal circles; legs never (♂) 4, 1, 2, 3, nor 1, 3, 2, 4; (♀) 4, 1, 3, 2, nor 4, 3, 1, 2.....ICIUS.
48. Metatarsi III and IV with spines throughout their length; legs (♂) 4, 1, $\overline{2, 3}$ or 1, 3, 2, 4; (♀) 4, 1, 3, 2 or 4, 3, 1, 2..... 49
49. Coxae I nearly touching; legs (♂) 4, 1, $\overline{2, 3}$; (♀) 4, 1, 3, 2; quadran-

---

[1] Spiders in this group except *Phidippus rufus*, *Philæus militaris*, and *Plexippus puerperus* are large, from 8 to 16 mm (commonly about 10 mm) in length. The sides of the cephalic part are usually much swollen.

[2] Our only species of *Admestina* is small, not more than 4 m m long.

[3] *Sadala* is distingulshed from *Icius* by having spines throughout the length of the metatarsi of the third and fourth legs, and by having the leg formula 1, 4, 2, 3. Our only species of *Sadala* is from Mexico.

gle of eyes ⅓ wider than long; middle anterior eyes touching; eyes of second row a little nearer the lateral than the dorsal eyes, CYRBA.

50. Coxae I separated by width of labium; legs (♂) 1, 3, $\overline{2, 4}$; (♀) 4, 3, 1, 2; quadrangle of eyes less than one third wider than long; middle anterior eyes subtouching; eyes of second row halfway between lateral and dorsal eyes.....CYTÆA.

51. First row of eyes straight[1] 35

52. First row of eyes curved 59

53. Middle eyes of first row touching..... 55

54. Middle eyes of first row not quite touching 57

55. Metatarsi III and IV with spines only in terminal circles; quadrangle of eyes equally wide in front and behind; eyes of second row half way between lateral and dorsal eyes.....EPIBLEMUM.

56. Metatarsi III and IV spined throughout their length; quadrangle of eyes wider behind; eyes of second row nearer the lateral than the dorsal eyes.....ATTUS E. S.

57. Lateral eyes of first row nearly touching middle eyes; eyes of second row nearer lateral than dorsal eyes; legs (♂) 1, 4, 2, 3; (♀) 4, 1, 3, 2.....PSEUDICIUS.[2]

58. Lateral eyes of first row separated by ⅓ their own diameter from middle eyes; eyes of second row not nearer lateral than dorsal eyes; legs (♂) 1, 3, 4, 2; (♀) 4, 3, 1, 2 .....HASARIUS.

59. Dorsal eyes nearer to each other than to lateral borders.....MÆVIA.

60. Dorsal eyes further from each other than from lateral borders.... 61

61. Quadrangle equally wide in front and behind; legs 4, 3, 2, 1..... ATTUS W.[3]

62. Quadrangle wider behind; legs not 4, 3, 2, 1.....DENDRYPHANTES.

The following tables are useful only for spiders described in this paper. They are designed to furnish an easy method for determining species. To use them, determine the relative length of the legs of the spider in question and find the corresponding formula in the tables. This will usually place the spider in a group of four or five genera, rendering it a comparatively easy matter to determine the genus. When the difference between two legs is extremely slight they are placed together with a dash above. The tables do not include the genera *Synemosyna*, *Synageles*, *Salticus* and *Lyssomanes; Dendryphantes multicolor* also does not appear since our only specimen has but three legs.

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[1] It requires practice to distinguish a straight from a slightly curved row of eyes, but since these genera are only represented by three species the difficulty will be inconsiderable. *E. scenicum* is a dark spider with two oblique white bands on each side of the abdomen; *A. palustris* has two white spots near the center of the dorsum of the abdomen; *A. imperialis* has four snowy white oblique bands on the face and falces and a ring of white on the distal end of the femur of the palpus.

[2] Our only species of this genus is from west of the Rocky Mountains.

[3] The species which we leave in *Attus Walck.* It being only represented by an immature specimen we do not determine its genus.

TABLE OF LEG FORMULÆ FOR MALES.

$1\ \overline{2\ 3\ 4}$

PLEXIPPUS puerperus.

$1\ 3\ \overline{2\ 4}$

CYTÆA minuta.

1 4 2 3

PHIDIPPUS mexicanus.
PHIDIPPUS arizonensis.
PHIDIPPUS insolens.
PHIDIPPUS johnsonii.
PHIDIPPUS octopunctatus.
PHILÆUS chrysis.
DENDRYPHANTES capitatus.
DENDRYPHANTES flavipedes.
ATTUS palustris.
ATTUS imperialis.
ICIUS albovittatus.
ICIUS palmarum.
HYCTIA pikei.
MARPTUSA familiaris.
MARPTUSA californica.
MENEMERUS melanagnathus.
HOMALATTUS cyaneus.
ZYGOBALLUS sexpunctatus.
ZYGOBALLUS bettini.
SADALA distincta.

1 4 3 2

ICIUS piraticus.
ICIUS mitratus.
MENEMERUS paykullii.
AGOBARDUS anormalis.

$4\ 1\ \overline{2\ 3}$

CYRBA tæniola.
BALLUS youngii.

$\overline{4\ 3}\ \overline{1\ 2}$

SAITIS pulex.

1 3 4 2

HASARIUS hoyi.
PROSTHECLINA cambridgii.

$1\ 4\ \overline{2\ 3}$

PHIDIPPUS rufus.
PHIDIPPUS morsitans.
PHIDIPPUS cardinalis.
PHILÆUS militaris.
DENDRYPHANTES elegans.
MÆVIA californica.
EPIBLEMUM scenicum.

$\overline{1\ 4}\ \overline{2\ 3}$

PSEUDICIUS harfordii.

$\overline{1\ 4}\ 3\ 2$

ASTIA morosa.

3 4 1 2

HABROCESTUM coronatum.
HABROCESTUM viridipes.
HABROCESTUM peregrinum.
HABROCESTUM auratum.
HABROCESTUM hirsutum.
HABROCESTUM splendens.
HABROCESTUM oregonense.

4 1 3 2

ASTIA vittata.
ADMESTINA wheelerii.

4 3 1 2

PLEXIPPUS putnamii.
NEON nellii.

$4\ 3\ \overline{2\ 1}$

ATTUS cautus.

TABLE OF LEG FORMULÆ FOR FEMALES.

1 4 2 3

ERIS octavus.
ERIS nervosus.
HYCTIA pikei.

1 4 3 2

DENDRYPHANTES flavus.

3 4 1 2

HABROCESTUM cœcatum.
HABROCESTUM viridipes.
HABROCESTUM cristatum.
HABROCESTUM auratum.
HABROCESTUM splendens.

$\overline{4}$ 1 2 3

ZYGOBALLUS bettini.

4 1 $\overline{2\ 3}$

PHIDIPPUS rauterbergii.
PHIDIPPUS miniatus.
PHILÆUS fartilis.
PHILÆUS militaris.
DENDRYPHANTES capitatus.
CYRBA tæniola.
MARPTUSA familiaris.
MARPTUSA californica.
BALLUS youngii.

4 3 1 2

HASARIUS hoyi.
PROSTHECLINA cambridgii.
ASTIA vittata.
CYTÆA minuta.
MENEMERUS melanognathus.
AGOBARDUS anormalis.

4 $\overline{3}$ $\overline{1}$ 2

ASTIA morosa.

$\overline{4\ 3}$ 1 2

PLEXIPPUS puerperus.

1 4 3 $\overline{2}$

PHILÆUS mexicanus.
ICIUS palmarum.

$\overline{1}$ $\overline{4}$ $\overline{2\ 3}$

PSEUDICIUS harfordii.

4 1 2 3

PHIDIPPUS morsitans.
PHIDIPPUS galathea.
PHIDIPPUS m'cookii.
PHIDIPPUS opifex.
DENDRYPHANTES alboimmaculatus.
ATTUS palustris.
ICIUS lineatus.

$\overline{4}$ $\overline{1}$ 3 $\overline{2}$

ICIUS mitratus.

4 1 3 2

PHIDIPPUS rufus.
PHIDIPPUS obscurus.
PHIDIPPUS insolens.
PHIDIPPUS albomaculatus.
PHIDIPPUS johnsonii.
PHIDIPPUS otiosus.
PHILÆUS farneus.
PHILÆUS chrysis.
PHILÆUS princeps.
PHILÆUS rimator.
DENDRYPHANTES elegans.
ERIS barbipes.
EPILBEMUM scenicum.

$\overline{4\ 3}$ $\overline{1\ 2}$

SAITIS pulex.

PHIDIPPUS (C. KOCH.)

Cephalothorax high and convex, contracted in front and behind, sides usually widely rounded, especially in ♂, cephalic part inclined forward, and separated from the thoracic by a depression; thoracic part slanting, at first gradually and then more steeply from the dorsal eyes. Quadrangle of eyes $\frac{1}{8}$ wider than long (excepting *arizonensis*, which is $\frac{1}{4}$ wider than long, and *opifex* which is $\frac{2}{3}$ wider than long), wider behind than in front; anterior eyes small, in a curved row, the middle not more than twice as large as the lateral, and but little separated; the lateral separated from them by from $\frac{1}{8}$ to $\frac{2}{3}$ their own diameter; eyes of second row twice as far from dorsal as from lateral eyes; eyes of third row about as large as lateral eyes, at least as far from each other as from the lateral borders. Third row of eyes narrower than the cephalothorax at that place. Clypeus from $\frac{1}{4}$ to $\frac{1}{2}$ as high as large middle eyes, vertical. Falces usually stout and nearly twice as long as face. Labium longer than wide, about $\frac{1}{2}$ as long as maxillae. Sternum deep set, projecting between the anterior coxæ which are separated by width of labium or a little less. Legs (♂) 1, 4, 2, 3; (♀) 4, 1, 2, 3, or 4, 1, 3, 2; first leg stoutest, with femur and tibia enlarged and compressed, stouter than patella, and much stouter than metatarsus and tarsus. Tibia and patella of the first usually a little shorter than cephalothorax; tibia and patella of the third shorter than tibia and patella of the fourth; tibia and patella of the fourth at least as long as metatarsus and tarsus of the fourth. Femoral, tibial, metatarsal and sometimes patellary spines on the four pairs; metatarsi of the fourth, spined throughout their length.

PHIDIPPUS MORSITANS WALCKENAER.

Plate I, figures 1, 1 a. Plate II, figure 1.

Syn.: 1837. ? ATTUS *morsitans* Walck., Hist. Nat. des Insectes Aptères, I. p. 432.
1844. " *audax* Hentz, Journal Boston Soc. Nat. Hist., Vol. IV.
1845. " *tripunctatus* id., ibid., Vol. V.
1846. PHIDIPPUS *variegatus* C. K., Die Arachn., XIII, p. 125.
1846. " *purpurifer* id., ibid., XIII, p. 127.
1846. " *smaragdifer* id., ibid., XIII, p. 128.
1846. " *alchymista* id., ibid., XIII, p. 131.
1846. " *rufimanus* id., ibid., XIII, p. 132.
1846. " *lunulatus* id., ibid., XIII, p. 133.
1846. " *mundulus* id., ibid., XIII, p 137.

Syn.: 1847. ATTUS *morsitans* Walck., Hist. Nat. des Insectes Aptéres, IV, p. 419.

1875. ATTUS *audax* HENTZ, Coll. Arachn. Writings ed. by Burgess, Boston, p. 50.

1875. " *tripunctatus* id., ibid., p. 58.

1883. " " Peckham, Descr. new or little known, Attidæ, p. 33.

♂. Total length 11 mm. Width of abdomen 4.3 mm.

Cephalothorax: length 5.3; width 5.1; height 2.8. Legs: 11, 9.1, 9.1, 10.7; patella and tibia of the first, 5.5; patella and tibia of the third, 3.2; patella and tibia of the fourth, 4; metatarsus and tarsus of the fourth, 4.

Lateral separated from middle eyes by ⅓ their diameter. Clypeus ⅓ as high as large as middle eyes. Maxillæ slightly diverging, wide at extremity, with a projection at the outer corner, inner margin slanting toward labium. Labium ⅓ as long as maxillæ, contracted and rounded at tip. Sternum convex, oval. Anterior coxæ separated by width of labium.

♀. Total length 15 mm. Width of abdomen 5.6 mm.

Cephalothorax: length 5.5; width 4.4; height 2.2.

Legs 10.6, 9, 9, 12.1; patella and tibia of the first, 4.2; patella and tibia of the third, 2.4; patella and tibia of the fourth, 3.2; metatarsus and tarsus of the fourth, 3.2.

Relative length of legs 4, 1, 2, 3.

Coloration. ♂. ♀. Cephalothorax black, covered with short black and gray hairs, and having some long black hairs on the sides near the small median eyes; there are sometimes white bands on the sides. Clypeus covered with white hairs. Femur of palpus reddish, with a black band on inner side, three black spines, and some black and white hairs. The falces are bright iridescent green, with reddish fangs. The sternum and venter are black, the venter having two whitish longitudinal bands which approach each other, but terminate near the apex without meeting. The abdomen is black, with thick, short, black hairs, and some long white hairs; at the middle point is a large, more or less triangular, white spot; posterior to this are two smaller, somewhat oblique, white spots; lower down, and nearer the apex than these, but in a line with them, are two minute white dots. The spots are formed by scales, which, through the microscope, look like grains of rice. In some specimens there are two oblique white bands on each side, and a white band at the base. Immature specimens frequently have the spots orange-colored instead of white. The legs are black and hairy, barred with rufus in young specimens; on the inner side of the patella of the first leg is a brush of white hairs.

Habitat. United States.

Although the markings of this spider are similar to those of *P. miniatus*, it has no red hairs when adult, and is thus easily distinguished from that

species. It is possible that *morsitans* grows larger in the western than in the eastern states, as Emerton gives 8.6 mm. as the total length of the ♀. A period of from fourteen to fifteen days is required for the development of the eggs of this species.

PHIDIPPUS RUFUS HENTZ.

Plate I, figure 2 a. Plate II, figure 2.

Syn.: 1845. ATTUS *rufus* H., Journal Boston Soc. Nat. Hist., Vol. V.
1845. " *castaneus* id., ibid., Vol. V.
1846. PLEXIPPUS *rufus* C. K., Die Arach., XIII, p. 120.
1846. " bi-vittatus id., ibid., XIII, p. 120.
1875. ATTUS *rufus* H., Coll. Arachn. Writ., ed. by Burgess, Boston, p. 60.
1875. " *castaneus* id., ibid., p. 55.
1885. PHIDIPPUS *ruber* Keyserling, Neue Spinnen aus Amerika, VI, Verhandlungen Zoologisch — botanischen gesellschaft, p. 7.

♂. Total length 8.5 mm. Width of abdomen 3 mm.

Cephalothorax: length 4.1; width, 3.4; height 2.5.

Legs, 9.9, 7.3, 6.8, 9.2; patella and tibia of the first 4.2; patella and tibia of the third 2.4; patella and tibia of the fourth 3.4; metatarsus and tarsus of the fourth 3.

Lateral rather more than one-half as large as middle eyes, separated from these by two-thirds their own diameter. Clypeus one-fourth as high as middle eyes. Maxillæ nearly parallel, enlarged at extremity, with projection at outer corner, slanting within toward labium. Labium a little more than one-half as long as maxillæ, contracted at tip. Sternum oval, convex, nearly twice as long as wide. Anterior coxæ separated by width of labium. Legs without patellary spines.

♀. Total length 11.8 mm. Width of abdomen 4.8.

Cephalothorax: length 5; width 3.8; height 2.7.

Legs 9.4, 8.1, 8.4, 9.9; patella and tibia of the first 3.8; patella and tibia of the third 3; patella and tibia of the fourth 3.5; metatarsus and tarsus of the fourth 3.4.

Maxillæ rounded at extremity; labium two-thirds as long as maxillæ; relative length of legs 4, 1, 3, 2.

Coloration. ♂. The cephalothorax is covered with bright yellowish-red hairs, excepting the lower sides which are white; there are some long black hairs in the eye region. The face, clypeus and palpi are covered with white hairs; the falces are dark iridescent green; the mouth parts and coxæ are dark reddish brown; the sternum is black with white hairs; the venter is black, with two longitudinal lines of white hairs which converge behind. The abdomen is covered with

red hairs like those on the cephalothorax; it has a white basal band which extends on to the sides, and four indented dots. The legs are dark reddish brown, with many white hairs.

♀. The color is much less brilliant than in the ♂, being usually of a dull brick-red hue. The abdomen, besides the white basal band, has an oblique white band on each side, and two black bands on the posterior dorsal parts: these black bands reach the apex, and curve toward each other anteriorly; each has a white dot at its anterior, and one at its posterior end, and a transverse white line across the middle, where it is widest. The legs are reddish brown with black rings.

In *cardinalis*, with which it might be confused, the clypeus is one-third not one-fourth, and the lateral anterior eye is separated by one-half not two-thirds of its own diameter from the large middle eye. The second and third legs in *cardinalis* are about equal; in *rufus* the second is plainly longer than the third.

Habitat: United States.

PHIDIPPUS GALATHEA WALCK.

Plate I. figures 3, 3a.

Syn.: 1837. ATTUS *galathea* Walck., Hist. Nat. des Insectes Aptères, I, p. 456.

1845. ATTUS *mystaceus* Hentz, Jour. Bost. Soc. of Nat Hist., Vol. V.

1846. PHIDIPPUS *asinarius* C. K., Die Arachniden, XIII, p. 139.

1847. ATTUS *galathea* Walck., Hist. Nat. des Insectes Aptères, IV, p. 422.

1875. ATTUS *mystaceus* Hentz. Coll. of Arachnological Writings, ed. by Burgess, p. 58.

♀ Total length 11.6 mm. Width of abdomen 4 mm.

Cephalothorax: length 5.2; width 3.8; height 2.

Legs 9.6, 8.5, 8, 10.6; patella and tibia of the first 4; patella and tibia of the third, 3; patella and tibia of the fourth, 3.9; metatarsus and tarsus of the fouth, 3.4.

Lateral separated from middle eyes by $\frac{2}{3}$ their own diameter. Clypeus $\frac{1}{3}$ as high as large middle eyes. Maxillæ widened and rounded at tip, nearly parallel. Labium $\frac{1}{2}$ as long as maxillæ, about twice as long as wide, contracted toward tip. Sternum widest in the middle. Anterior coxæ separated by scarcely the width of the labium. Relative length of legs 4, 1, 2, 3.

Coloration: Cephalothorax black, covered with heavy gray hairs, and two tufts of black hairs on each side of the eye region. Abdomen covered with gray hairs with two pairs of white spots on the anterior part of the dorsum; when somewhat rubbed a blackish, scalloped band ap-

pears which occupies the central region. Clypeus covered with white hairs; palpi, legs, sternum, and venter with gray hairs: falces iridescent green: mouth parts reddish brown.

Habitat: Eastern United States.

PHIDIPPUS CARDINALIS HENTZ.

Plate II, figure 4.

Syn.: 1844. ATTUS *cardinalis* Hentz, Journal Boston Soc. Nat. Hist., p. 386.

1875. ATTUS *cardinalis* id., Coll. of Arachn. Writ. ed. by Burgess, Boston, p. 51.

1883. ATTUS *cardinalis* Peckham, Descr. new or little known Attidæ, p. 31.

♂. Total length 9.5 mm. Width of abdomen 3 mm.

Cephalothorax: length 4.1; width 4; height 2.8.

Legs 11.1, 8.2, 8.2, 10.7; patella and tibia of the first 4.5; patella and tibia of the third, 3; patella and tibia of the fourth, 3.6; metartarsus and tarsus of the fourth, 3.3.

Lateral separated from middle eyes by ½ their own diameter; four anterior eyes looking downward. Clypeus ⅓ as high as middle eyes. Maxillæ enlarged and blunt at extremity with a projection at the outer corner, and parallel. Labium ⅓ as long as maxillæ, a little longer than wide, blunt and slightly contracted at tip. Sternum, widest in middle, ¼ longer than wide. Anterior coxæ separated by scarcely the width of the labium.

Coloration: Cephalothorax, abdomen, and venter entirely covered with brilliant red hairs; there are four indented dots on the anterior part of the abdomen, and sometimes two longitudinal black bands each with two red dots, extending from the middle of the dorsum to the spinnerets, and converging a little behind.

Habitat: Southern United States.

PHIDIPPUS MINIATUS PECKHAM.

Plate I, figures 6, 6a.

Syn.: 1883. ATTUS *miniatus* P., Descr. new or little known Attidæ of U. S., p. 15.

♀. Total length 13 mm. Width of abdomen 5 mm.

Cephalothorax: length 5.9; width 5; heighth 3.8.

Legs 13.5, 10.7, 10.7, 13.7; patella and tibia of the first, 5.5; patella and tibia of the third, 3.8; patella and tibia of the fourth, 5.1; metatarsus and tarsus of the fourth, 4.

Large ♀. Total length 18 mm.

Anterior row of eyes very little curved; lateral $\frac{1}{3}$ as large as middle eyes separated from them by $\frac{2}{3}$ their own diameter; dorsal a little smaller than lateral eyes, a little further from each other than from lateral borders. Clypeus about $\frac{1}{3}$ as high as middle eyes. Maxillæ enlarged and rounded at extremity, diverging. Labium a little more than $\frac{1}{3}$ as long as maxillæ, contracted and truncated at tip. Sternum not so wide as anterior coxæ. Anterior coxæ separated by width of labium. Relative length of legs 4, 1, $\overline{2, 3}$; no patellary spines.

Coloration: The cephalothorax has the eye-region covered with short, bright red hairs, intermixed with long black hairs, the latter forming small tufts between the small median and dorsal eyes; the thoracic part and sides are covered with coarse yellowish white hairs; the narrow lower margin is black. The abdomen has a wide band of gray hairs around the base, and is otherwise covered with short bright red, and long whitish hairs; at about the middle of the dorsum is a large somewhat triangular spot, and behind this are two others, not so large and transversely elongated, all of the same bright red color, and encircled by black rings; the sides are covered with long gray hairs. In specimens which are kept in alcohol the color becomes faded, the red changing to whitish yellow. The clypeus and palpi are covered with long white hairs; the legs are blackish, excepting the metatarsi, which are reddish brown; they are covered with gray hairs; under the femur is a stout fringe of hairs which extends less heavily on to the patella and tibia; the falces are dark, but very iridescent; the mouth-parts, sternum, and coxæ are dark brown or black; the venter has a wide central, longitudinal band black, limited by the gray hairs which come low on the sides; just at the apex, between the black band and the black spinnerets, is a narrow, transverse band of gray hairs.

Habitat: Florida. Texas.

PHIDIPPUS OBSCURUS Nov. Sp.

Plate I, figure 5. Plate II, figure 5.

(♀) Total length 13 mm. Width of abdomen 5.4 mm.

Cephalothorax: length 4.8; width 4.1; height 2.4.

Legs 9.3, 7.5, 7.7, 10; patella and tibia of the first 4; patella and tibia of the third 2.8; patella and tibia of the fourth 3.9; metatarsus and tarsus of the fourth 3.4.

Lateral eyes $\frac{1}{3}$ as large as middle eyes, and separated from them by $\frac{2}{3}$ their own diameter. Clypeus $\frac{1}{3}$ as high as middle eyes. Maxillæ wide at extremity with projection at outer corner. Labium $\frac{1}{3}$ as long as maxillæ, contracted and rounded at tip. Falces rather narrower than is usual in this genus, extending, in width only to the inner

edges of the lateral eyes. Sternum oval, convex. Anterior coxae separated by scarcely the width of the labium. Patellary spines on the second, third and fourth legs.

Coloration: Cephalothorax black, covered on the sides and above anterior row of eyes with white hairs, and having a transverse band of yellow hairs extending between the dorsal eyes. Abdomen with a dark brown band extending around the lower base and sides to apex; above this, at the base is a shorter curved pale band; central region of dorsum dark brown, changing toward the anterior portion to black, and marked, in this region with a pair of elongated white spots; behind these is a large white spot; behind this and near the apex is a pair of pale curved bands which take the form of a parenthesis, nearly meeting in the middle line. The dark central region of the dorsum surrounded excepting behind, by a pale region mottled with brown; opposite the large white spot on each side, is an oblique white band which extends downward through the encircling dark band. Legs and palpi brown, covered (especially the palpi) with white hairs. Venter pale, sternum, coxae and mouthparts brown, all clothed with white hairs. Falces iridescent green.

The curved white bands on the posterior part of the dorsum sometimes meet anteriorly, extending a little forward to form a chevron.

Habitat: Texas.

PHIDIPPUS McCOOKII PECKHAM.

Plate II, figure 9.

Syn.: 1883. ATTUS *McCookii* P., Descr. new or little known Attidæ of U. S., p. 16.

♀. Total length 14.4 mm. Width of abdomen 6 mm.

Cephalothorax: length 4.9; width 4.2; height 2.5.

Legs 10.7, 8, 8.2, 11; patella and tibia of the first 4; patella and tibia of the third 2.7; patella and tibia of the fourth 4.3; metatarsus and tarsus of the fourth 3.

Lateral eyes of the first row one-half as large as middle eyes, and separated from them by more than one-half their own diameter. Dorsal eyes, a little further from each other than from the lateral borders. Clypeus one-third as wide as middle eyes. Maxillæ parallel, enlarged and rounded at extremity. Labium nearly two-thirds as long as maxillæ, widest in middle, rather pointed. Sternum convex, about twice as long as wide. Anterior coxæ separated by a little less than the width of the labium. Relative length of legs 4, 1, 2, 3.

Coloration: Cephalothorax dark rufus covered with tawny hair. Abdomen golden yellow with short hairs of the same color; there are four indented dots near the base, and posterior to these two indistinct dark

bands extend to the apex; the sides are creased (the abdomen is distended with eggs in the only specimen which we have of this species). Clypeus and palpus dark rufus with long white hairs. Falces, mouthparts, sternum and legs dark rufus, the inner edges of maxillae and tip of labium being pale, and the legs having blackish bars. Venter golden yellow with three iridescent dark bands.

Habitat: Pennsylvania.

PHIDIPPUS ARIZONENSIS PECKHAM.

Plate I, figure 10. Plate II, figure 10.

Syn.: 1883. ATTUS *arizonensis* P., Descr. new or little known Attidæ of U. S., p. 13.

♂. Total length 11 mm. Width of abdomen 3 mm.

Cephalothorax: length 4.9; width 4.2; height 2.

Legs 11.4, 9.9, 9.9, 10.3; patella and tibia of the first 4.9; patella and tibia of the third 3.6; patella and tibia of the fourth 4.1; metarsus and tarsus of the fourth 3.

Cephalic part with sides very widely rounded.

Ocular area about one-half wider than long, this being relatively wider than is usual in *Phidippus*. Anterior lateral one-half as wide as middle eyes, and separated from them by their own diameter. Clypeus two-thirds as high as middle eyes. Dorsal eyes nearly twice as far from each other as from lateral borders. Maxillæ parallel, enlarged at extremity, with the outer corner sharp; labium one-half as long as maxillæ, rounded. Sternum as wide as imtermediate coxæ. Anterior coxæ much stouter and longer than the others, and separated by the width of the labium. There are sometimes patellary spines on the four pairs. Abdomen long and slender, with its posterior face truncated; spinnerets turned downward.

Coloration: Cephalothorax velvety black, with two wide, white, lateral bands beginning just before and below the dorsal eyes and almost meeting in the middle of the thorax behind the depression. There is a band of grayish brown hairs above the anterior eyes, and a tuft of black hairs near each small median eye. Abdomen light brown; behind the middle is a median, longitudinal velvety black band, the truncated face, and the spinnerets being also black; in the middle of the dorsum is a pair of indented dots, and a second pair, just in front of these, is very indistinct; at the apex are two white spots one on each side of the black band; on each upper side of the abdomen is a black line extending to the apex; the under sides have wide white bands, formed of hairs directed downwards, which extend beneath on to the venter. The venter is velvety black, darkest behind, the white bands marking it off into a long triangle. Cly-

peus covered with white hairs; sternum, coxae and mouthparts black; falces black with some white hairs on the anterior surface; palpi and legs yellowish, excepting the femur I which is black above and pale beneath; third and fourth pairs darker than first and second, and showing some reddish rings on patella and tibia. All the legs have, on the under side, long, fine, yellow hair, which is strikingly long and thick on the first pair.

The abundance of fine yellowish hairs on the undersides of the first pair of legs, together with the great distance between the anterior lateral and large middle eyes distinguishes it from all other species of this genus.

Habitat: Arizona, Texas, California.

PHIDIPPUS ALBOMACULATUS KEYS.

(Plate I, figure 13. Plate II, figure 13.)

Syn: 1885. PHIDIPPUS *albomaculatus* Keyserling, Neue Spinnen aus Amerika, vi, Verhandlungen Zoologisch-botanischen gesellschaft, p. 5 (491).

♀. Total length 13.4 mm. Width of abdomen 5.3 mm.

Cephalothorax: length 6; width 4.3; height 3.2.

Legs 13.5, 10.7, 10.6, 14; patella and tibia of the first, 5.6; patella and tibia of the third, 4; patella and tibia of the fourth, 5.3; metatarsus and tarsus of the fourth, 4.5.

Anterior lateral eyes scarcely one-half as large as middle eyes, and separated from them by two-thirds of their own diameter; dorsal eyes equally distant from each other and the lateral borders. Clypeus one-third as high as middle eyes. Maxillæ parallel, enlarged and rounded at extremity; labium a little more than one-half as long as maxillæ, oval, or a little contracted at tip. Sternum long, narrow, pointed in front, very convex. Anterior coxæ separated by less than the width of the labium. Relative length of legs, 4, 1, 3, 2; no patellary spines.

Coloration: Cephalathorax dark brown, entirely covered with short white hairs, and having some long, black and white hairs on the eye-region. Abdomen with a large, dark central region, in which is a median, forked, white band, and two pairs of white dots, while the sides have a mottled appearance, being covered with mixed white and brown hairs; usually there may be distinguished two or three oblique white bands extending downward over the sides. The pattern on the dorsum is frequently indistinct owing to the rubbing off of hairs; frequently all that appears is two dark longitudiual bands, on each of which are three or four white dots. Clypeus with a thick fringe of white hairs; falces most brilliantly iridescent; mouth-parts blackish; sternum, coxæ, and venter brown, covered with short, white hairs; palpi and legs yellowish brown, all covered with thick, long, white hair.

Habitat: United States.

PHIDIPPUS OPIFEX McCook.

Plate II, figure 11.

Syn.: 1873. Attus *opifex* McCook, Proc. Acad. Nat. Sci. of Philadelphia, p. 276.

♀. Total length, 15 mm. Width of abdomen, 7 mm.

Cephalothorax: length, 6.3; width, 4.9; height, 3.5.

Legs 13.3, 11.1, 10.4, 14.2; patella and tibia of the first, 5.2; patella and tibia of the third, 3.8; patella and tibia, fourth, 5.2; metatarsus and tarsus of the fourth, 4.7.

Quadrangle of eyes two-thirds wider than long. Lateral anterior eyes more than one-half as large as middle eyes, separated from them by two-thirds their own diameter. Middle eyes plainly separated. Clypeus one-half as high as middle eyes. Falces wider than the two middle eyes, three times as long as face, inclined forward, divergent. Maxillæ parallel, enlarged and blunt at extremity, slanting within toward labium. Labium one-half as long as maxillæ. Sternum projecting but little between anterior coxæ. Anterior coxæ separated by width of labium.

Coloration: Cephalothorax dark reddish, covered with white hair, and having a black marginal line. Clypeus and face covered with long white hairs. Abdomen black, covered with gray hair, with four white dots on the anterior part of the dorsum. Falces black with white hairs at base. Mouth-parts brown. Stermum, coxæ and venter covered with white hairs. Palpi light reddish brown, with long white hairs. Legs banded with black and dark reddish brown, with some white hairs, especially below. The hairs on cephalothorax, abdomen and venter are scale-like.

Habitat: California.

PHIDIPPUS JOHNSONII Peckham.

Plate I, figure 14. Plate II, figures 14, 14a.

Syn.: Attus *johnsonii* P., Descr. new or little known Attidæ of U. S., p. 22.

♂. Total length 10 mm. Width of abdomen 3.2 mm.

Cephalothorax: length 5.1; width 3.3; height 2.1.

Legs 10.9, 8.6, 8.9, 10.9; patella and tibia of the first, 4.8; patella and tibia of the third, 3.2; patella and tibia of the fourth, 4; metatarsus and tarsus of the fourth, 3.3.

Lateral eyes of first row one-half as large as middle eyes, and separated from them by half their own diameter. Clypeus half as high as middle eyes. Maxillæ parallel, with sharp outer corners, and slanting within toward the labium. Labium a little longer than wide, more than one-

half as long as maxillæ, contracted and rounded at tip. Sternum oval, half longer than wide. Anterior coxæ separated by width of labium. No patellary spines.

♀. Total length 12.2 mm. Width of abdomen 3.9 mm.

Cephalothorax: length 4.3; width 2.8; height 2.1.

Legs 10.4, 8.4, 8.4, 11.1; patella and tibia of the first, 4.3; patella and tibia of the third, 3.6; patella and tibia of the fourth, 4.5; metatarsus and tarsus of the fourth, 3.5.

Clypeus one-third as high as middle eyes. Maxillæ rounded. Sternum relatively wider than in ♂. Anterior coxæ separated by less than the width of the labium.

Coloration: ♂. Cephalothorax jet black, sometimes with a few short bright red hairs (perhaps, in a fresh state, entirely covered with these). Abdomen bright vermillion red, sometimes with a white band at base; clypeus dark with a fringe of white hairs; palpus black; falces dark but iridescent; maxillæ and labium brown; sternum black with white hairs; venter dark brown with white hairs; legs dark rufus barred with black. ♀. Abdomen with a white band at base, and a wide central longitudinal black band, upon which are three pairs of white dots.

This species is nearest *cardinalis;* it is, however, not so high; its color is crimson rather than scarlet; and on the anterior inner edge of the falx is a sharp, rather long point, which in *cardinalis* is but little developed. The cephalothorax in *cardinalis* is covered with scarlet hairs, in *johnsonii* it is jet black. The latter also has on the palpi of the first pair of legs many white, rice-like scales or hairs.

Habitat: Washington Territory.

PHIDIPPUS OCTO-PUNCTATUS PECKHAM.

Plate II, figure 15.

Syn.: 1883. P. *octo-punctatus* Peckham, Descr. new or little known Attidæ of U. S., p. 6.

♂. Total length 8 mm. Width of abdomen 2.8 mm.

Cephalothorax: length 3.1; width 3; height 2.3.

Legs 8.4, 5.6, 5.9, 7.9; patella and tibia of the first, 3.2; patella and tibia of the third, 2; patella and tibia of the fourth, 2.9; metatarsus and tarsus of the fourth, 2.8.

Lateral anterior a little more than ½ as large as middle eyes, separated from them by ½ their own diameter. Clypeus ⅓ as high as middle eyes. Falces wider than first row of eyes, three times as long as face. Maxillæ short, truncated, with projection at outer corner, inclined toward labium. Labium ½ as long as maxillæ, ½ longer than wide, contracted and blunt at tip. Anterior coxæ separated by more than width of labium.

Coloration: Cephalothorax above, black covered with short white hairs, sides dark brown with some irregular whitish spots and sparse yellowish hairs, the lower margin being slightly darker; there are some long yellow hairs on the eye-region. Clypeus dark brown mottled with white, with a few yellowish hairs. Abdomen black covered with short white hairs and longer yellowish hairs; near the base is a short curved white line, posterior to which are two longitudinal rows of white spots, four spots in each row; these are divided into two anterior and two posterior pairs, the four posterior spots being obliquely elongated; on the posterior sides are two or three short oblique white lines. Falces, mouth-parts, sternum, coxæ and legs dark brown. Venter black with short yellowish hairs.

Habitat: Missouri.

PHIDIPPUS RAUTERBERGII Nov. Sp.

Plate I, figure 8. Plate II, figure 8.

♀. Total length 16 mm. Width of abdomen 7.3 mm.

Cephalothorax: length 6.2; width 5.8; height 3.8.

Legs 15.3, 11.3, 11.3, 15.2; patella and tibia of the first, 6.4; patella and tibia of the third, 4.4; patella and tibia of the fourth, 6; metatarsus and tarsus of the fourth, 5.1.

Cephalothorax nearly plane; ocular area much wider behind; anterior lateral one-half as large as middle eyes, and separated from them by a little more than one-half their own diameter; eyes of second row more than twice as far from dorsal as from lateral eyes; third row of eyes considerably narrower than the cephalothorax at that place; clypeus one-third as high as the middle eyes. Maxillæ wide, parallel, rounded. Labium one-half as long as maxillæ, but little longer than wide, blunt at tip. Sternum oval, convex in front, less than twice as long as wide, projecting but little between the anterior coxæ, which are separated by less than the width of the labium. Relative length of legs $\overline{4, 1}$, $\overline{2, 3}$; no patellary spines.

Coloration: Cephalothorax dark reddish brown, almost black in the eye-region, with some short white hairs on the sides and between the dorsal eyes. Abdomen mottled with brown and white, with two black spots on the anterior portion, and one large irregular black spot in the middle from which two black bands extend to the apex; in the middle of the black spot is a large white spot, and on the black bands, is a pair of smaller white spots; there are sometimes two white dots nearer the apex, and a white spot on the inner side of each of the black spots on the anterior part of the dorsum, while the space between the black bands is occupied by a series of white and brown chevrons. Clypeus brown; palpus brown with three white rings;

falces iridescent; mouth-parts, sternum, and coxæ reddish brown; venter with two white longitudinal bands enclosing a darker central region; legs black, barred with dark red, with short white hairs, and a heavy fringe of black hairs on the underside of the tibia of the first.

Habitat: Texas.

PHIDIPPUS MEXICANUS Nov. Sp.

Plate II, figure 7.

♂. Total length 11.4 mm. Width of abdomen 5 mm.

Cephalothorax: length 6.5; width 5; height 3.6.

Legs 16.3, 12.7, 11.2, 14.5; patella and tibia of the first, 6.7; patella and tibia of the third, 4; patella and tibia of the fourth, 5.3; metatarsus and tarsus of the fourth, 4.8.

Cephalothorax widely rounded. First row of eyes much curved; lateral separated from middle eyes by one-half their own diameter. Clypeus one-fourth as high as large middle eyes. Falces wider than first row of eyes, more than twice as long as face. Maxillæ long, widened and truncated at extremity, with projection at outer corner, cut obliquely on inner side, and excavated for labium. Labium less than half as long as maxillæ, contracted and blunt at tip. Sternum one-half longer than wide. Anterior coxæ separated by a little less than width of labium.

Coloration: Cephalothorax probably covered with snowy white hairs, excepting a dark brown band around the margin; in our specimen these hairs are largely rubbed off. Clypeus with white hairs. Abdomen black with a hairy white band at base, a large central white spot behind middle, and posterior to this an interrupted, curved, white band. Falces brilliant iridescent green. Palpi covered with white hairs. Legs very hairy; femoral and tibial joints with black, other joints with white hairs. Other parts all black.

From the collection of Count Keyserling.

Habitat: Mexico.

PHIDIPPUS INSOLENS Hentz.

Plate I, figure 12. Plate II, figures 12, 12a.

Syn.: 1844. Attus *insolens* Hentz, Journal Bost. Soc. Nat. Hist., Vol. IV.
1845. " *podogrosus* id., ibid., Vol. V.
1875. " *insolens* id., Coll. Arach. Writ. by N. M. Hentz. Ed. by Burgess, Boston, p. 51.
1875. " *podogrosus* id., ibid., p. 61.
1877. Phidippus *coloradensis* Thorell, Descr. Araneæ coll. in Colorado, p. 523.

♂. Total length 9.5 mm. Width of abdomen 3 mm.

Cephalothorax: length 5; width 4; height 2.4.

Legs 14, 9, 8, 10.2; patella and tibia of the first, 6.3; patella and tibia of the third, 2.8; patella and tibia of the fourth, 3.2; metatarsus and tarsus of the fourth, 3.

Small ♂. Total length 6.8 mm.

♀. Total length 12mm. Width of abdomen 4.5.

Cephalothorax: length 4.8; width 4; height 2.5.

Legs 9.2, 7.8, 8, 10; patella and tibia of the first, 4.2; patella and tibia of the third, 3; patella and tibia of the fourth, 4; metatarsus and tarsus of the fourth, 3.3.

Anterior lateral separated from middle eyes by one-half their own diameter. Middle nearly twice as large as lateral eyes, and a little separated. Clypeus one-third as high as middle eyes. Maxillæ long inner margin oblique, ♂ with marked apophysis on outer corner, ♀ enlarged and blunt at extremity. Sternum nearly twice as long as wide. Anterior coxæ separated by less than the width of the labium.

Coloration: Cephalothorax covered with bright red hairs excepting the lower margin which has a white line above a black line; the ♀ has a tuft of black hairs on the outer side of each lateral eye. Clypeus with some long white hairs. Abdomen with a silvery white band at base behind which is a deep black band; the dorsum is of a bright red color, which is interrupted in the posterior two-thirds by a central, longitudinal, angular, black band which is contracted behind, upon which, in the posterior part, are two pairs of white dots; the sides are black with two curved white bands. Palpi ♂ black, conspicuously marked by a silvery white line along the upper surface. ♀ reddish with long white hairs. Falces brilliant iridescent green, those of the ♂ with a slight brownish tinge; fang black. Mouthparts dark brown. Sternum and coxæ black with white hairs. Venter deep black with white hairs on the sides, and, in the center, a wide somewhat triangular band (narrowing behind), of a clear silvery white color. Legs banded with black and rufus. In the ♂ the first leg has fringes of black hairs; in the ♀ the same leg is covered with long white hairs.

The hairs in this species seem to rub off even more easily than is usual with the Attidæ. When they are gone the spider appears as in Hentz's drawing.

In general appearance *insolens* is much like *Philœus rimator*, but may be distinguished by the difference in the shape of the cephalothorax, and the position of the eyes.

Habitat: Georgia, Florida, Colorado.

PHIDIPPUS OTIOSUS HENTZ.

Plate I, figure 15. Plate II, figure 15 a.

Syn.: 1845. ATTUS *otiosus* Hentz, Journal Boston Soc. Nat. Hist., Vol V.
1875. ATTUS *otiosus* id., Coll. Arachn. Writ. by N. M. Hentz. Ed. by Burgess, Boston, p. 59.

♀. Total length 11.5 mm. Width of abdomen 4 mm.

Cephalothorax: length 5; width 4; height 2.5.

Legs 9.6, 7.5, 8, 10; patella and tibia of the first 4; patella and tibia of the third, 3.4; patella and tibia of the fourth 4; metartarsus and tarsus of the fourth, 3.8.

Lateral eyes of first row one-half as large as middle eyes and separated from them by one-third their own diameter. Clypeus one-half as high as middle eyes. Maxillæ enlarged and rounded at extremity. Labium two-thirds as long as maxillæ. Falces nearly as wide as first row of eyes, as long as face, vertical, diverging. Sternum, very deepset, oval, projecting between the anterior coxæ which are separated by the width of the labium.

Coloration: A wide band of white hairs extends across the clypeus and on to the sides, under the eyes, nearly encircling the cephalothorax; above is a black band which occupies the cephalic part, but grows narrower on the thoracic, where the white band curves upward. On each side of the cephalothorax are two tufts of black hairs, one between the eye of the second row and the dorsal eye, and one just behind and below the anterior lateral eye. Abdomen black with a band of long white hairs at base, and several lines of white hairs on each side; on the anterior part of the dorsum are two white dots; on he middle part and nearer together, are two larger white spots; near the apex are two large curved spots of a light yellowish red color; these with the white spots, and the lines on the sides mark off a somewhat irregular black figure on the posterior part of the dorsum. Falces darkly iridiscent with a fringe of white hairs at their insertion. Palpi and legs black with long white hairs. Mouth-parts, sternum, coxæ and venter black, the venter nearly encircled by white hairs which form wide white bands on the sides, and with two white spots in the middle.

This is a very hairy species, in this respect, and in its general coloring, resembling *P. galathea*.

Habitat: Georgia, Alabama.

PHILÆUS (THORELL).

Cephalothorax high and convex, contracted in front and behind, sides rounded, cephalic part inclined forward, thoracic part slanting, at first gradually, and then more steeply from dorsal eyes. Ocular area

at least one-third wider than long, wider behind than in front; anterior row of eyes more or less curved, the middle slightly separated, the lateral at least one-half as large, separated from the middle by from one-third to two-thirds their own diameter; eyes of second row very slightly nearer the lateral than the dorsal eyes; dorsal as large or nearly as large as the lateral eyes, at least as far from each other as from the lateral borders, forming a row narrower than the cephalothorax at that place. Clypeus not more than half as high as middle eyes. Labium about one-half as long as maxillæ, usually longer than wide, sometimes as wide as long. Anterior coxæ separated by width of labium or by a little less. Legs (♂) 1, 2, 4, 3. 1, 4, 2, 3. 1, 4, 3, 2; (♀) 1, 4, 2, 3. 1, 4, 3, 2. 4, 1, 3, 2; first pair stoutest, second next. Femur and tibia of the first enlarged, stouter than patella and much stouter than metatarsus and tarsus; tibia and patella of the third shorter than tibia and patella of the fourth. Femoral, tibial and metatarsal spines on the four pairs; metatarsi of the fourth usually spined throughout their length.

This genus differs from *Phidippus* in having the eyes of the second row nearly half way between the lateral and dorsal eyes; the width of the ocular area, moreover, is frequently greater in proportion to its length.

PHILÆUS FARNEUS Nov. Sp.

Plate II, figure 16.

♀. Total length 9.2 mm. Width of abdomen 3.2 mm.

Cephalothorax: length 4; width 3.4; height 2.1.

Legs 8.4, 6.6, 7.2, 9.2; patella and tibia of the first, 3.6; patella and tibia of the third, 2.8; patella and tibia of the fourth, 3.6; metatarsus and tarsus of the fourth, 3.1.

Cephalic part plane, and but little inclined: thoracic convex, falling abruptly a little way behind dorsal eyes. Ocular area one-third wider than long, much wider behind than in front. Anterior eyes small, in a moderately curved row; lateral one-half as large as middle eyes, separated from them by two-thirds their own diameter; dorsal a little smaller than lateral eyes, further from each other than from lateral borders. Clypeus one-third as high as middle eyes, vertical; falces as wide as first row of eyes, twice as long as face, vertical, diverging. Maxillæ parallel, enlarged and rounded at extremity. Labium a little more than one-half as long as maxillæ, about twice as long as wide, contracted and blunt at tip. Sternum twice as long as wide, deepset, a little rounded behind. Anterior coxæ separated by less than width of labium.

Coloration: Cephalothorax black with long stiff black hairs on the eye-region, which form one or two small tufts on each side. Clypeus covered with short white hairs. Abdomen black, encircled except at

apex by a scalloped white band; on the middle of the dorsum is a large triangular white spot, in front of, and behind which are two white dots; near the apex, extending upward from the encircling band, are two short oblique white bars. Palpi reddish with long white hairs. Falces iridescent purple. Mouth-parts, sternum and coxæ dark brown. Venter black in the middle with a whitish longitudinal band on each side. Legs dark brown with long black and gray hairs.

Habitat: Texas.

PHILÆUS FARTILIS Nov. Sp.

Plate II, figure 17.

♀. Total length 10 mm. Width of abdomen 4 mm.

Caphalothorax: length 4.4; width 3.8; height 2.4.

Legs 9, 7.2, 7.3, 9.5; patella and tibia of the first, 4; patella and tibia of the third, 2.8; patella and tibia of the fourth, 3.6; metatarsus and tarsus of the fourth, 3.3.

Ocular area one-third wider than long; anterior eyes small, in a slightly curved row; middle eyes more than twice as large as lateral eyes, separated from them by one-half the diameter of the lateral; dorsal as large as lateral eyes, further from each other than from lateral borders. Clypeus one-third as high as middle eyes, vertical. Falces as wide as first row of eyes, more than twice as long as face, vertical, slightly diverging. Maxillæ divergent, enlarged and rounded at extremity, excavated on inner side for labium. Labium a little more than one-half maxillæ, one-half longer than wide, a little contracted and truncated at tip. Sternum one-half longer than wide, rather deep set. Anterior coxæ separated by less than width of labium. Legs 1, 4, 2, 3; metatarsi of the third and fourth with only terminal circles of spines.

Coloration: Cephalothorax and clypeus covered with long white hairs, the former with a black marginal line. Abdomen gray except the posterior part which is blackish; the base and anterior sides are white; there is a large irregular reddish spot on each side, and on the dorsum are indistinctly marked three pairs of white spots. Near the apex on each lower side is a wide white band, and on the upper surface is a white parenthesis, the black region enclosed having a pair of white dots. Falces black, the upper part being covered with long white hairs. Mouth parts, sternum and coxæ, black. Venter white with a wide, central, longitudinal black band. Legs and palpi dark brown covered with long white hairs.

Habitat: Mexico.

PHILÆUS MEXICANUS Nov. Sp.

Plate I, figure 18. Plate II, figure 18.

♀. Total length 10 mm. Width of abdomen 3.1 mm.

Cephalothorax: length 4; width 3.2; height 2.

Legs 8.3, 6.4, 6.4, 7.8; patella and tibia of the first, 3.4; patella and tibia of the third, 2.8: patella and tibia of the fourth, 3.2; metatarsus and tarsus of the fourth, 2.4.

Ocular area occupying nearly two-fifths of cephalothorax, one-third wider than long; anterior row of eyes very little curved; lateral one-half as large as middle eyes, separated from them by one-half their own diameter; middle eyes sub-touching; dorsal as large as lateral eyes, equally distant from each other and the lateral borders. Clypeus a little inclined, one-fifth as high as the middle eyes. Falces stout and rather long, inclined forward, and somewhat diverging. Maxillæ parallel, enlarged and rounded at extremity; labium two-thirds as long as the maxillæ, pointed. Sternum convex, nearly as wide as long, truncated in front. Anterior coxæ separated by scarcely the width of the labium, much the stoutest and longest. First legs much the stoutest.

Coloration: Cephalothorax dark brown in the thoracic region, and blackish on the cephalic plate; the lower margin has a fine black line between two fine white lines; there is a wider band of white hairs which passes around the face and extends on the sides, below the second and third rows of eyes, to the posterior margin. Dorsum of the abdomen bronze brown; a little behind the middle are four white dots, two on each side. Around the base is a wide white band; on each side, opposite the dots, is a large white spot; on each side, near the apex, is a short, wide, ribbon-like white band, extending from below on to the dorsum, and bifurcating at the end; this makes a diamond-shaped figure of the bronze color, which connects a small bronze-colored region at the apex with the larger region of the same color on the anterior part of the dorsum. First and second pairs of legs darkest in color; all the legs brown, banded with blackish; tibia of the first leg black with a fringe of black hairs below. Clypeus covered with gray hairs. Falces dark brown. Mouthparts, coxæ, sternum, and venter, brown, thinly covered with gray hairs.

Habitat: Mexico.

PHILÆUS MILITARIS Hentz.

Plate I, figures 19, 19a. Plate II, figures 19, 19a.

Syn.: 1844. Attus *militaris* H., Journal Bost. Soc. Nat. Hist., Vol. IV.
1846. Eris *aurigera* (♂) C. K., Die Arachn., XIII, p. 189.
? 1846. Phidippus *asinarius* id., ibid., XIII, p. 139.
1875. Attus *militaris* H., Coll. Arachn. Writ. by N. M. Hentz, ed. by Burgess, Boston, p. 62.

♂. Total length 6 mm. Width of abdomen 1.9 mm.

Cephalothorax: length 2.1; width 1.9; height 1.8.

Legs 7.5, 3.8, 3.9, 4.6; patella and tibia of the first, 3.2; patella and tibia of the third, 2.1; patella and tibia of the fourth, 2.1; metatarsus and tarsus of the fourth, 2.1.

Falces 1.6.

Ocular area one-third wider than long; anterior eyes small, lateral more than one-half as large as middle eyes, and separated from them by one-half their own diameter; dorsal a little smaller than lateral eyes, and further from each other than from the lateral borders. Clypeus one-fourth as high as middle eyes. Falces nearly as wide as the first row of eyes, long, inclined forward, and diverging, fang long. Maxillæ narrow at base, wider at extremity, long, truncated, slanting on the inner edge, and excavated for labium; labium less than one-half as long as maxillæ, longer than wide, a little contracted and rounded at the extremity. Sternum nearly twice as long as wide, truncated in front and rounded behind. Anterior coxæ separated by scarcely the width of the labium.

♀. Total length 9.4 mm. Width of abdomen 4.1 mm.

Cephalothorax: length 3.2; width 2.4; height 1.6.

Legs 5.9, 4.7, 4.7, 5.7; patella and tibia of the first, 2.1; patella and tibia of the third, 1.8; patella and tibia of the fourth, 1.9; metatarsus and tarsus of the fourth, 1.9.

Falces parallel and vertical, shorter and less robust than in ♂; fang short. Maxillæ enlarged and rounded at extremity; labium more than one-half as long as maxillæ, twice as long as wide.

Coloration: ♂. Cephalothorax and abdomen bright bronze brown, the former with a wide white band on each upper side, and a white spot in the middle of the eye region, the latter with a wide white band around the base and sides, and sometimes two rows of white dots on the dorsum; clypeus, falces, palpi, mouthparts and sternum dark brown; venter brown, covered with short white hairs; legs brown, with femur of the first very dark, and proximal parts of the femora of the second, third and fourth, and all the coxæ, light yellowish.

♀. Cephalthorax bronze, nearly covered with gray hairs, the abdomen with a whitish band down the middle, and four pairs of more or less elongated white spots; the lower sides are nearly white; clypeus covered with long white hairs; falces, mouthparts and sternum brown; venter brown with short white hairs and a darker central region; legs and palpi light brown, with white hairs.

Habitat: United States, Mexico.

PHILAEUS CHRYSIS WALCK.

Plate I, figure 20. Plate II, figure 20. Plate III, figure 20a.

Syn.: 1837. ATTUS *chrysis* (♂) Walck., Hist. Nat. des Insectes Aptères, I, p. 454.
1837. " *iris* (♀) Walck., id., ibid., p. 455.
1846. PLEXIPPUS *aurecalceus*, C. K., Die Arachniden, XIII, p. 113.
1847. ATTUS *chrysis* Walck., Hist. Nat. des Insectes Aptères, IV, p. 422.
1847. " *iris*, id., ibid., p. 423.

♂. Total length 9 mm. Width of abdomen 2.8 mm.

Cephalothorax: length 3.9; width 3.5; height 2.8.

Legs 13.7, 9.5, 9.4, 10.9; patella and tibia of the first, 5.7; patella and tibia of the third, 3.4; patella and tibia of the fourth, 4.4; metatarsus and tarsus of the fourth, 3.2.

Falces 3 mm.

Ocular area one-third wider than long; anterior row of eyes very little curved; lateral rather more than one-half as large as middle eyes, and separated from them by one-half their own diameter; dorsal smaller than lateral eyes, and equally distant from each other and the lateral borders. Clypeus one-fourth as high as middle eyes. Falces compressed, as wide as the middle eyes, two and one-half times as long as the face, inclined forward, and diverging; the fang is two-thirds as long as the falx. Maxillæ parallel, long, truncated, with a projection at the outer corner; labium blunt, one-half longer than wide, and one-half as long as the maxillæ. Sternum truncated in front, rounded behind, one-fourth longer than wide. Anterior coxæ separated by width of labium. Relative length of legs 1, 4, $\overline{2,\ 3}$.

♀. Total length 10.9 mm. Width of abdomen 4.2 mm.

Cephalothorax: length 4.2: width 3.8; height 2.1.

Legs 9.2, 7.9, 8.1, 9.4; patella and tibia of the first, 4.1; patella and tibia of the third, 2.8; patella and tibia of the fourth, 3.5; metatarsus and tarsus of the fourth, 3.

Falces 1.9 mm.

Falces vertical, parallel, and not so long as in ♂; maxillæ rounded; labium more than one-half as long as maxillæ; anterior coxæ separated by more than the width of the labium. Relative length of legs 4, 1, 3, 2.

Coloration: As well as it can be distinguished from our badly rubbed specimens, the coloration is as follows: ♂, cephalothorax black; abdomen black, encircled, excepting at the apex, by a white band, and with two pairs of white spots, or rather of short transverse white lines, on the posterior part of the dorsum; the under side of the body, and the legs, black, or very dark brown. ♀, cephalothorax black; abdomen covered with golden scales, with a white band around the

anterior margin which extends on to the sides, a short oblique white line on each side at the termination of this band, and posterior to these lines, on each side a semi-circular band, white; the dorsum has, on the anterior part, four indented dots, and on the posterior part, opposite the oblique lines one pair of short transverse white lines like those of the ♂; the mouthparts and falces are black, the sternum and coxæ dark brown; the venter is brown with a central longitudinal white band; the legs are light brown excepting the femoral, patellary, and tibial joints of the first pair, which are black.

Habitat: Mexico, Guatemala. (South Carolina, Georgia, Walckenaer.)

PHILÆUS PRINCEPS PECKHAM.

Plate III, figure 21.

Syn.: 1883. ATTUS *princeps* P., Descr. new or little known Attidæ of U. S., p. 18.

♀. Total length 8.1 mm. Width of abdomen 3 mm.

Cephalothorax: length, 3.9; width, 3.2; height, 2.

Legs 7.1, 5.9, 6, 7.5; patella and tibia of the first, 3.4; patella and tibia of the third, 2; patella and tibia of the fourth, 2.6; metatarsus and tarsus of the fourth, 2.4.

Ocular area nearly twice as wide as long, and much wider behind; anterior row a little curved, the eyes composing it being unusually small, the lateral about one-half as large as the middle, and separated from them by nearly two-thirds their own diameter; dorsal almost as large as lateral eyes, and further from each other than from the lateral borders. Clypeus, one-third as high as middle eyes. Falces as wide as the first row of eyes, nearly twice as long as the face, vertical, slightly diverging. Maxillæ parallel, enlarged and blunt at extremity, slanting on the inner edge to the labium; labium less than one-half as long as maxillæ, as wide as long, a little contracted and truncated at tip. Sternum deep set, small, one-half longer than wide, widest in the middle. Anterior coxæ separated by less than the width of the labium. Relative length of legs, 4, 1, 3, 2.

Coloration: ♀. Cephalothorax dark rufus, covered with short yellowish white hairs, and having some long black hairs on the eye region; abdomen covered with coarse tawny and gray hairs, with a whitish band at base, and two gray spots, one on either side of the middle point of the dorsum. Clypeus with thick white hairs; falces darkly iridescent; mouthparts brown; maxillæ tipped with white; sternum black; venter with grayish yellow hairs; legs, palpi, and spinnerets bright reddish brown, the legs and palpi with white hairs.

Habitat: Pennsylvania.

PHILÆUS RIMATOR WALCK.

Plate I, figure 22.

Syn.: 1837. ? ATTUS *rimator* Walck., Hist. Nat. des Insectes Aptères, I, p. 446.

1846. PHIDIPPUS *auctus* C. K., Die Arachniden, XIII, p. 148.

1847. ATTUS *rimator* Walck., His. Nat. des Insectes Aptères, IV, p. 422.

1883. " *formosus* Peckham, Descr. new or little known Attidæ, of U. S., p. 23.

♀. Total length 8.4 mm. Width of abdomen 2.9 mm.

Cephalothorax: length 4; width 2.9; height 2.

Legs 7, 5.2, 4.9, 7.5; patella and tibia of the first, 3; patella and tibia of the third, 1.7; patella and tibia of the fourth, 2,7; metatarsus and tarsus of the fourth, 2.

Ocular area one-third wider than long; anterior row of eyes slightly curved; lateral rather more than one-half as large as middle eyes, and separated from them by two-thirds their own diameter; eyes of this row unusually small; eyes of second row very minute; dorsal eyes a little smaller than the lateral, and placed further from each other than from the lateral borders. Clypeus one-half as high as middle eyes. Falces as wide as the first row of eyes, once and one-half as long as the face, vertical and a little divergent. Maxillæ parallel, enlarged and blunt at extremity, cut a little on the inner edge; labium one-half as long as maxillæ, twice as long as wide, contracted and rounded at tip. Sternum deepset, oblong, narrow in front, one-half longer than wide. Anterior coxæ separated by scarcely the width of the labium.

Coloration: ♀. Cephalothorax and abdomen covered with bright red hairs, the abdomen with a white band around the base, and a wide, central, longitudinal, black band which begins in front of the middle of the dorsum and extends around the lower, posterior sides; upon this band are three pairs of white dots. Clypeus and palpi covered with red hairs; falces brilliant green; mouthparts, sternum and coxæ varying from brown to black; venter black; legs brownish with some red hairs.

Habitat: Pennsylvania, Florida, Iowa.

PLEXIPPUS PUERPERUS HENTZ.

Plate I, figures 23, 23a. Plate II, figure 23a. Plate III, figure 23b.

Syn.: 1845. ATTUS *puerperus* Hentz, Journal Boston Soc. Nat. Hist., Vol. V.

1845. " *sylvanus* id., ibid., Vol. V.

1846. ALCMENA *pallida* C. K., Die Arachn., XIII, p. 179.

1874. ATTUS *branickii* Tacz., Les Araneides de la Guyane française, Horae Soc. Entomol. Ross. T., VIII, p. 94.

1875. ATTUS *puerperus* Hentz, Coll. Arachn. Writ. Ed. by Burgess, p. 64.

1879. MARPISSA *branickii* Tacz., Les Aranéides du Pérou. Bull. Soc. Imp. des Nat. de Moscou. T. LIII, p. 227.

1883. ATTUS *agrestis* Peckham, Descr. new or little know Attidæ of U. S., p. 12.

1885. PLEXIPPUS *puerperus* id., Proc. Nat. Hist. Soc. of Wisconsin, p. 68.

As Dr. Taczanowski has kindly sent us specimens of his *Attus branickii* we have been able to compare them with *puerperus* Hentz. They are undoubtedly identical. We have the same spider in our own collection, from Central America.

♂. Total length[1] 11 mm. Width of abdomen 2.4 mm.

Cephalothorax: length 4; width 2.4; height 2.8.

Legs 12.3, 10.3, 10.5, 10.8; patella and tibia of the first 5.4; patella and tibia of the third 3.9; patella and tibia of the fourth, 3.8; metatarsus and tarsus of the fourth, 3.9.

♀. Total length 13.6 mm. Width of abdomen 4.7 mm.

Cephalothorax: length 4.8; width 4.2; height 2.8.

Legs 10.6, 9.1, 10.4, 11.7; patella and tibia of the first, 4.8; patella and tibia of the third, 3.9; patella and tibia of the fourth, 4.1; metatarsus and tarsus of the fourth, 4.3.

Cephalothorax high, rounded on the sides and widest behind the dorsal eyes. The cephalic part occupies two-fifths of the cephalothorax; it is nearly plane and slightly inclined. The thoracic part is somewhat rounded but falls steeply from the dorsal eyes. The ocular area is one-fourth wider than long and is a little wider behind than in front. The anterior row is moderately curved: the middle eyes are sub-touching and are scarcely twice as large as the lateral eyes, the lateral being separated from the middle by one-third their own diameter. The eyes of the second row are placed not quite as far from the dorsal as from the lateral eyes. The dorsal eyes are a little smaller than the lateral eyes and are placed by more than their own diameter in-

[1] The size of the male is very variable, ranging from 5.6 mm., total length, to 11 mm.

side the margin: they are further from each other than from the lateral borders. The clypeus is one-third as high as the large middle eyes. The falces are stout, being a little wider than the first row of eyes, and are flattened in front; they are nearly twice as long as the face, parallel and vertical. The fang is short. The maxillæ are long and parallel, enlarged and slightly rounded at the extermity. The labium is but little longer than wide, a little more than one-half the maxillæ, contracted and rounded at the tip. Sternum one and one-half times as long as wide, truncated in front and rounded behind. It projects between the anterior coxæ which are separated by the width of the labium. Legs, relative stoutness, first, second, third, fourth; the fourth being plainly more slender than the third. There are femoral, patellary, tibial and metatarsal spines on the four pairs, those on the tibiæ and metatarsi of the third and fourth being found both above and below, and those on the metatarsi extending to the base. The ♀ has no patellary spines on the first and second pairs.

Coloration: (♂.) The cephalothorax varies from reddish brown to black and has on the dorsum a central spot of white, two white lines on each side near the posterior border, running upward from the lower margin, and just behind and below each dorsal eye two short parallel white lines; the abdomen varies from light testaceous to dark brown and has on the dorsum two longitudinal white bands; on each side of the bands are some scattered black dots. The legs and falces are dark brown; the clypeus is dark brown above with a pale band just over the falces; on the upper portion two lines of white hairs beginning between the middle eyes run obliquely outward to the insertion of the palpi; the palpus is brown, with a white line above, meeting that on the clypeus. The sternum, coxæ and mouthparts vary from light testaceous to dark brown; the venter is brown with a longitudinal white line on each side. (♀) The cephalothorax is yellow, darkest in the eye region, the eyes are jet black, the small middle eye is on a black spot, thus offering a striking contrast to the light yellow of the cephalothorax; there is a brown spot just above the anterior middle eyes; the abdomen is light yellow with three longitudinal white bands, the middle band often less distinct, and many black dots. The legs, palpi, falces and clypeus are yellow, the sternum, coxæ and venter pale brown, the venter having a line of white hairs on each side.

Habitat: California, Florida, Texas, Georgia (Gentry collection), Mexico, Guatemala, New Grenada (in collection of Count Keyserling), Brazil.

PLEXIPPUS PUTNAMII PECKHAM.

Plate III, figure 24.

Syn.: 1883. ATTUS *putnamii* P., Descriptions of new or little known Attidæ, p. 1.

♂. Total length 9 mm. Width of abdomen 2.6 mm.

Cephalothorax: length 4.5; width 3.3; height 2.3.

Cephalothorax high, convex, widest just behind dorsal eyes; cephalic a little shorter than thoracic part; rounded on the sides and slanting abruptly behind. Ocular area nearly twice as wide as long; wider behind than in front; anterior row of eyes a little curved; lateral $\frac{1}{3}$ as large as middle eyes, and separated from them by $\frac{2}{3}$ their own diameter, while the middle eyes are slightly separated from each other; eyes of the second row a very little nearer the lateral than the dorsal eyes; dorsal nearly as large as lateral eyes, further from each other than from the lateral borders, forming a row which is a little narrower than the cephalothorax at that place. Clypeus $\frac{1}{3}$ as high as middle eyes. Falces extending in width to inner edges of lateral eyes, square, $1\frac{1}{3}$ times as long as the face, vertical, parallel; fang small. Maxillæ parallel, truncated at tip, cut obliquely on the inner edges; labium $\frac{1}{3}$ as long as maxillae, as wide as long, pointed. Sternum very deep-set, oval, projecting between the anterior coxæ, which are separated by less than the width of the labium. Relative length of legs 4, 3, 1, 2; first and second pairs stoutest. Femur of the first rather short, narrow at the ends, and much enlarged below, in the middle. All the legs have femoral, tibial and metatarsal spines, and there are patellary spines on the third and fourth; metatarsi of the fourth spined throughout their length.

Coloration: Cephalothorax reddish brown; there is a large white spot just behind the dorsal eyes, and a short white band on each side of the eye-region extending from the smaller median to the dorsal eyes; just back of the small median eye is a tuft of black hairs; there are thick, light brownish hairs above the anterior row of eyes. Abdomen light reddish brown, encircled by a white band; near the apex two short, transverse, parallel, white bars, on each side, extend from the encircling band toward the middle of the abdomen; at about the middle point of the dorsum is a large white spot, and near the base are two small, indistinct, white spots formed by a few white hairs. Clypeus covered with short red and long white hairs. Palpus brownish, with black and white hairs. Mouthparts, sternum and coxæ dark brown, sternum and coxæ covered with white hairs. Venter covered with whitish hairs, with a central, longitudinal, darker band. Legs brownish red with many long white hairs.

Habitat: Iowa.

DENDRYPHANTES CAPITATUS HENTZ.

Plate I, figures 25, 25a. Plate III, figure 25a.

Syn.: 1844. ATTUS *capitatus* H., Journal Bost. Soc. Nat. Hist., Vol. IV.
1845. ATTUS *parvus* (♀) id., ibid. Vol. V.
1875. ATTUS *parvus* (♀) id., Coll. Arachn. Writ. by N. M. Hentz. Ed. by Burgess, Boston, p. 62.
1875. ATTUS *capitatus* id., ibid., p. 51.
1883. ATTUS *æstivalis* Peckham, Descr. new or little known Attidæ of U. S., p. 2.

♂. Total length 4.8 mm. Width of abdomen 1.4 mm.

Cephalothorax: length 2.1; width 1.5; height 1.2.

Legs 4.1, 3, 2.6, 3.9; patella and tibia of the first, 1.9; patella and tibia of the third, 9; patella and tibia of the fourth, 1.7; metatarsus and tarsus of the fourth, 9.

Cephalothorax high, convex, slightly dilated behind dorsal eyes; cephalic part inclined, but little shorter than thoracic. Ocular area one-third wider than long, a little wider behind than in front; first row of eyes a little curved; lateral a little less than one-half as large as middle eyes, and slightly separated from them; middle eyes sub-touching; eyes of second row a very little nearer lateral than dorsal eyes; dorsal eyes further from each other than from lateral borders. Clypeus one-third as high as middle eyes, retreating. Falces extending to inner edges of lateral eyes, flattened, once and a half as long as face, vertical, somewhat diverging; fang moderately long and stout. Maxillæ parallel, long, enlarged and rounded at extremity, with a projection at the outer corner; labium less than half as long as maxillæ, contracted and rounded at tip. Sternum oval, twice as long as wide, narrow at both ends. Anterior coxæ separated by a little more than the width of the labium; considerably longer than the others. Legs relatively long; first pair stoutest. Femoral, tibial and metatarsal spines on the four pairs; on the metatarsi of the fourth throughout their length.

♀. Total length 6.2 mm. Width of abdomen 2.3 mm.

Cephalothorax: length 2; width 1.5; height 8.

Legs 3.5, 2.8, 2.5, 4.3; patella and tibia of the first, 1.3; patella and tibia of the third, 9; patella and tibia of the fourth, 1.7; metatarsus and tarsus of the fourth, 9.

Middle anterior only twice as large as lateral eyes; lateral not so much separated from middle eyes as in ♂. Falces parallel, fang short and weak. Maxillæ parallel, without projection at outer corner; labium more than once and one-half as long as maxillæ. Anterior coxæ separated by scarcely the width of the labium and not so long as in ♂.

Coloration: ♂. Cephalothorax bronze brown with three longitudinal white bands on each side; the highest of these is much the widest and ex-

tends from the anterior lateral eye to the posterior border; the middle band has its origin on the upper surface of the caput and passing down between the middle and lateral eye of the first row curves backward and extends along the side of the cephalothorax through about half its length; the lowest of the bands is the narrowest; it begins opposite the origin of the palpus, and passes backward just above the lower border, terminating a little beyond the middle band. A wide vertical white band passes between the anterior middle eyes from the upper surface of the caput to the origin of the falces. Abdomen bronze brown, nearly encircled by a white band which extends around the base and sides and ends abruptly just above and in front of the spinnerets. Clypeus, falces, mouthparts and sternum brown; venter brown with three white bands, one on each side, and one connecting these at the apex.

♀. Cephalothorax brown with short white hairs. Abdomen very variable; sometimes pinkish with white bands at base and on the sides, and four pairs of white spots; sometimes brown with many pale spots and curved bands; sometimes brown with four pairs of black spots (resembling *E. octavus*); sometimes bronze with white hairs at base and on the sides, and two longitudinal black bands upon which are three or four pairs of white dots (resembling *P. militaris*). Clypeus white. Other parts varying between light and dark brown.

This species is much like *P. militaris*, but is easily distinguished from it by the difference in size, *P. militaris* being considerably larger. The male sometimes retains the markings of the female, these being proper to it in the immature stage. It was a male of this kind that we described as new under the name of *A. æstivalis*.

Habitat: United States. Mexico.

DENDRYPHANTES ELEGANS HENTZ.

Plate III, figures 26, 26a, 26b. Plate IV, figure 26c.

Syn.: 1845. ATTUS *elegans* H. (♀), Jour. Bost. Soc. Nat. Hist., Vol. V.
1845. " *superciliosus* id. (♂), ibid., Vol. V.
1848. MAEVIA *cristata* C. K. (♂), Die Arachn., XIV, p. 70.
1875. ATTUS *elegans* H. (♀), Coll. Arachn. Writ. by N. M. Hentz, Ed. by Burgess, Boston, p. 56.
1875. " *superciliosus* id. (♂), ibid., p. 68.
1883. " *tibialis* Peckham (♂), Descr. new or little known Attidæ of U. S., p. 11.

♂. Total length 4.3 mm. Width of abdomen 1.1 mm.

Cephalothorax: length 1.9; width 1.2; height .8.

Legs 5.4, 3.2, 3.2, 5; patella and tibia of the first, 2; patella and tibia of the third, 1.2; patella and tibia of the fourth, 1.9; metatarsus and tarsus of the fourth, 1.6.

♀. Total length 5.5 mm. Width of abdomen 2 mm.

Cephalothorax: length 2.1; width 1. 2; height 1.

Legs 3.7, 3.1, 3.4, 4.3; patella and tibia of the first, 1.3; patella and tibia of the third, 1.1; patella and tibia of the fourth, 2; metatarsus and tarsus of the fourth, 1.6.

Cephalothorax moderately high, convex, dilated behind dorsal eyes; sides nearly vertical in cephalic, rounded in thoracic part; cephalic part inclined, especially in ♂; thoracic part slanting gradually for the first three-fifths of its length, then steeply. Ocular area occupying about two-fifths of cephalothorax, one-fourth wider than long, slightly wider behind than in front; first row of eyes on a ridge, curved (more in ♂ than in ♀): middle eyes sub-touching; lateral one-half as large as middle eyes, separated from them by one-half their own diameter; eyes of second row halfway between dorsal and lateral eyes; ♂ with two ridges of stout hairs oblique and converging, extending from eyes of second row to anterior middle eyes; dorsal as large as lateral eyes, further from each other than from lateral borders, forming a row as wide as the cephalothorax at that place. Clypeus vertical, scarcely one-fourth as high as the middle eyes. Falces (♂) extending to inner edges of lateral eyes, (♀) nearly as wide as first row, a little longer than face, parallel, vertical; fang weak; maxillæ parallel, enlarged and (♂) truncated, (♀) rounded at extremity; labium about one-half as long as maxillæ, as wide as long, rounded and much contracted at tip; sternum one and one-half times as long as wide, truncated in front, contracted and rounded behind; anterior coxæ separated (♂) by width of labium, (♀) by less; legs all fine and glabrous, first a little the stoutest; femur of the third long; very weak tibial and metatarsal (and in ♂ femoral) spines on the four pairs; on metatarsi of the third and fourth only in terminal circles.

Coloration: ♂. Cephalothorax black in eye region, reddish on sides and thoracic part, entirely covered with light green iridescent scales, excepting a narrow black line between two white lines around the margin; two whitish tufts of hairs above anterior eyes. Abdomen and venter covered with green iridescent scales. Clypeus iridescent; falces brown; sternum black with white hairs; mouthparts and coxæ brown; palpi and legs light brown, legs with a black longitudinal line above, first and second darker than third and fourth; tibia of the first black at distal end, with a strong black spine and a brush of black hairs. ♀. Cephalothorax dark, covered with iridescent scales, excepting marginal lines as in ♂. Abdomen dark and highly iridescent, with a whitish band around base and anterior sides. Clypeus iridescent; falces, palpi, mouthparts, sternum and coxæ as in ♂. Venter iridescent; legs pale with black lines as in ♂, excepting femur of the first which is dark.

Habitat: Middle, Eastern and Southern United States.

DENDRYPHANTES FLAVUS Nov. Sp.

Plate I, figure 27. Plate III, figures 27, 27 a.

♀. Total length 6.2 mm. Width of abdomen 1.8 mm.

Cephalothorax: length 2.7; width 2; height 1.2.

Legs 4.6, 3.5, 3.8, 4; patella and tibia of the first, 2; patella and tibia of the third, 1.6; patella and tibia of the fourth, 1.6; metatarsus and tarsus of the fourth, 1.2.

Cephalothorax not high, convex, dilated at the dorsal eyes, with sides rounded more widely behind than in front; cephalic part inclined. Ocular area occupying a little more than one-third of cephalothorax, one-third wider than long, wider behind than in front; anterior eyes looking downward, in a slightly curved row; middle eyes sub-touching; lateral less than one-half as large as middle eyes, separated from them by one-half their own diameter; eyes of second row a little nearer the lateral than the dorsal eyes; dorsal as large as lateral eyes, further from each other than from lateral borders, forming a row as wide as the cephalothorax at that place. Clypeus only a line. Falces nearly as wide as first row of eyes, two and one-half times as long as face, a little inclined forward, parallel; fang short. Maxillæ parallel, one-half as long as falces, enlarged and rounded at extremity. Labium a little more than one-half as long as maxillæ, longer than wide, rounded. Sternum deep set, twice as long as wide, truncated in front, rounded behind. Anterior coxæ separated by width of labium; coxæ of the first and second much the stoutest. Legs of the first and second stoutest, with femoral joints compressed, and having a single row of spines above, and several at the extremity; there are femoral, tibial, metatarsal, and sometimes small patellary spines on all the legs; metatarsi of the fourth spined to the base.

Coloration: Cephalothorax covered with yellow hairs, with a transverse brown band at dorsal eyes, and, around the margin, a white line between two black lines. Clypeus covered with white hairs. Abdomen covered by yellow hairs which have a somewhat metallic lustre, and having two longitudinal black bands, on each of which are three white dots. Falces, mouthparts and sternum dark brown, with some white hairs. Coxæ light brown. Palpi covered with gray hairs. Legs brown with gray hairs, and tipped with black. Venter brown with gray hairs.

Habitat: New York.

DENDRYPHANTES MULTICOLOR HENTZ.

Plate III, figures 28, 28a.

Syn.: 1844. ATTUS *multicolor* H., Jour. Bost. Soc. Nat. Hist,. Vol. IV.
1875. " " id., Coll., Arachn. Writ. by N. M. Hentz. Ed. by Burgess, Boston, p. 53.

♀. Total length 6.8 mm. Width of abdomen 2.4 mm.

Cephalothorax: length 3; width 2.5; height 1.5.

Legs 6.1, ——, 4.9, 6.1; patella and tibia of the first, 2.7; patella and tibia of the third, 1.9; patella and tibia of the fourth, 2.2: metatarsus and tarsus of the fourth, 2.1.

Cephalothorax high, convex, a little dilated behind dorsal eyes, with sides rounded more widely behind than in front, cephalic part inclined; thoracic part falling slightly in the first half, and much more steeply in the second. Ocular area occupying nearly one-half the cephalothorax, one-third wider than long, wider behind than in front. First row of eyes on a ridge, slightly curved; middle eyes sub-touching; lateral one-half as large as middle eyes, separated from them by nearly one-half their diameter; second row a little nearer lateral than dorsal eyes; dorsal nearly as large as lateral eyes, further from each other than from lateral borders, forming a row a little narrower than the cephalothorax at that place. Clypeus one-fifth as high as middle eyes, vertical. Falces extending to inner edges of lateral eyes, twice as long as face, vertical, parallel; fang short. Maxillæ parallel, dilated and rounded at extremity. Labium one-half as long as maxillæ, a little longer than wide, contracted and rounded at tip. Sternum nearly twice as long as wide, a little more contracted behind than in front, narrowest in the middle. Anterior coxæ separated by nearly the width of the labium. Legs of the first stoutest, with femoral joints enlarged and compressed. Femoral, tibial and metatarsal spines on the four pairs; metatarsi of the fourth spined throughout their length.

Coloration: Our single specimen of this species being badly injured, we quote the following description from Hentz:

"Cephalothorax black, with a pale, irregular band each side of the disc; abdomen metallic green, with a band at base, and a diagonal spot each side, orange, and with eight small white spots; underneath obscure gray, with inflections of green on the pectus; feet rufous or pale, varied with piceous $\overline{1.\ 4.}\ \overline{2.\ 3.}$ This species is related to *A. otiosus* and *mystaceus*, but distinct from both by the absence of the tufts of hair on the cephalothorax, and other characters. The palpi are pale yellow, and there is a black band more or less visible on each side of the abdomen."

Habitat: Pennsylvania, Alabama.

DENDRYPHANTES ALBO-IMMACULATUS PECKHAM.

Plate III, figure 29.

Syn.: 1883. ATTUS *albo-immaculatus* P., Descr. new or little known Attidæ of U. S., p. 5.

♀. Total length 5 mm. Width of abdomen 2 mm.

Cephalothorax: length 1.8; width 1.3; height .8.

Legs 3.2, 2.6, 2.4, 3.9; patella and tibia of the first, 1.1; patella and tibia of the third, 8; patella and tibia of the fourth, 1.4; metatarsus and tarsus of the fourth, 1.3.

Cephalothorax rather low, slightly convex, a very little dilated at dorsal eyes, sides almost vertical, posterior margin truncated; cephalic part slightly inclined; ocular area occupying two-fifths of cephalothorax, nearly one-third wider than long, wider behind than in front. Anterior eyes small, in a slightly curved row; middle eyes touching; lateral a little less than one-half as large as middle eyes, separated from them by one-half their own diameter; eyes of second row very small, slightly nearer the lateral than the dorsal eyes; dorsal a little larger than lateral eyes, further from each other than from lateral borders, forming a row as wide as the cephalothorax at that place. Clypeus vertical, one-third as high as middle eyes. Falces as wide as first row of eyes, twice as long as face, vertical, parallel; fang short. Maxillæ parallel, long, enlarged and rounded at extremity; labium one-fourth longer than wide, one-half as long as maxillæ, contracted and rounded at tip. Sternum twice as long as wide, contracted and truncated in front. Anterior coxæ separated by nearly the width of the labium. Femur, patella and tibia — especially tibia — of the first enlarged; femur with a row of short and strong black hairs near the middle of the lower border; patella with two circles of white hair separated by a hairless median part; the tibia has, on the upper border, a short ridge of strong black hairs, and on the lower border a longer ridge, the hairs below being as long as the articulation is thick; metatarsus and tarsus slender. Weak femoral, tibial and metatarsal spines on the four pairs, on the metatarsi of the third and fourth only in terminal circles.

Coloration: Cephalothorax and abdomen closely covered with short white hairs, with a few, scattered, long black hairs; clypeus, falces, palpi, sternum, coxæ and venter covered with white hairs; mouthparts pale; first leg brown, excepting the tibia, which is black; other legs light brown with longitudinal lines of white hairs.

Habitat: Iowa, New York.

side the margin: they are further from each other than from the lateral borders. The clypeus is one-third as high as the large middle eyes. The falces are stout, being a little wider than the first row of eyes, and are flattened in front; they are nearly twice as long as the face, parallel and vertical. The fang is short. The maxillæ are long and parallel, enlarged and slightly rounded at the extermity. The labium is but little longer than wide, a little more than one-half the maxillæ, contracted and rounded at the tip. Sternum one and one-half times as long as wide, truncated in front and rounded behind. It projects between the anterior coxæ which are separated by the width of the labium. Legs, relative stoutness, first, second, third, fourth, the fourth being plainly more slender than the third. There are femoral, patellary, tibial and metatarsal spines on the four pairs, those on the tibiæ and metatarsi of the third and fourth being found both above and below, and those on the metatarsi extending to the base. The ♀ has no patellary spines on the first and second pairs.

Coloration: (♂.) The cephalothorax varies from reddish brown to black and has on the dorsum a central spot of white, two white lines on each side near the posterior border, running upward from the lower margin, and just behind and below each dorsal eye two short parallel white lines; the abdomen varies from light testaceous to dark brown and has on the dorsum two longitudinal white bands; on each side of the bands are some scattered black dots. The legs and falces are dark brown; the clypeus is dark brown above with a pale band just over the falces; on the upper portion two lines of white hairs beginning between the middle eyes run obliquely outward to the insertion of the palpi; the palpus is brown, with a white line above, meeting that on the clypeus. The sternum, coxæ and mouthparts vary from light testaceous to dark brown; the venter is brown with a longitudinal white line on each side. (♀) The cephalothorax is yellow, darkest in the eye region, the eyes are jet black, the small middle eye is on a black spot, thus offering a striking contrast to the light yellow of the cephalothorax; there is a brown spot just above the anterior middle eyes; the abdomen is light yellow with three longitudinal white bands, the middle band often less distinct, and many black dots. The legs, palpi, falces and clypeus are yellow, the sternum, coxæ and venter pale brown, the venter having a line of white hairs on each side.

Habitat: California, Florida, Texas, Georgia (Gentry collection), Mexico, Guatemala, New Grenada (in collection of Count Keyserling), Brazil.

PLEXIPPUS PUTNAMII PECKHAM.

Plate III, figure 24.

Syn.: 1883. ATTUS *putnamii* P., Descriptions of new or little known Attidæ, p. 1.

♂. Total length 9 mm. Width of abdomen 2.6 mm.

Cephalothorax: length 4.5; width 3.3; height 2.3.

Cephalothorax high, convex, widest just behind dorsal eyes; cephalic a little shorter than thoracic part; rounded on the sides and slanting abruptly behind. Ocular area nearly twice as wide as long; wider behind than in front; anterior row of eyes a little curved; lateral ¼ as large as middle eyes, and separated from them by ⅔ their own diameter, while the middle eyes are slightly separated from each other; eyes of the second row a very little nearer the lateral than the dorsal eyes; dorsal nearly as large as lateral eyes, further from each other than from the lateral borders, forming a row which is a little narrower than the cephalothorax at that place. Clypeus ⅛ as high as middle eyes. Falces extending in width to inner edges of lateral eyes, square, 1¼ times as long as the face, vertical, parallel; fang small. Maxillæ parallel, truncated at tip, cut obliquely on the inner edges; labium ½ as long as maxillae, as wide as long, pointed. Sternum very deep-set, oval, projecting between the anterior coxæ, which are separated by less than the width of the labium. Relative length of legs 4, 3, 1, 2; first and second pairs stoutest. Femur of the first rather short, narrow at the ends, and much enlarged below, in the middle. All the legs have femoral, tibial and metatarsal spines, and there are patellary spines on the third and fourth; metatarsi of the fourth spined throughout their length.

Coloration: Cephalothorax reddish brown; there is a large white spot just behind the dorsal eyes, and a short white band on each side of the eye-region extending from the smaller median to the dorsal eyes; just back of the small median eye is a tuft of black hairs; there are thick, light brownish hairs above the anterior row of eyes. Abdomen light reddish brown, encircled by a white band; near the apex two short, transverse, parallel, white bars, on each side, extend from the encircling band toward the middle of the abdomen; at about the middle point of the dorsum is a large white spot, and near the base are two small, indistinct, white spots formed by a few white hairs. Clypeus covered with short red and long white hairs. Palpus brownish, with black and white hairs. Mouthparts, sternum and coxæ dark brown, sternum and coxæ covered with white hairs. Venter covered with whitish hairs, with a central, longitudinal, darker band. Legs brownish red with many long white hairs.

Habitat: Iowa.

except a white line just under the eyes, and a fringe of white hairs. Abdomen with a narrow central longitudinal brown band, on either side of which the dorsum is black; in the center of the dorsum are two transverse white bars or large spots, one on each side, in front of which are one or two dots on each side, while behind them, in the middle line are two indistinct light dots, one behind the other; just above the apex are two white bars corresponding to the middle bars but narrower; the lower sides are light brown or gray, and the base is sometimes whitish. Falces, mouthparts and coxæ dark brown. Sternum black. Venter gray with two longitudinal brown bands. Palpi and legs dark brown. ♀. Cephalothorax gray with a white cross behind dorsal eyes and a white band low on each side. Clypeus covered with white hairs. Abdomen gray at base, white at apex; near the base and close together are two large black spots, in the middle of each of which is a white dot; continuous with these spots are two narrow black bands, which curve outward and then inward, enlarging into two posterior spots, which are joined in the middle by a short black band which curves forward; the central region thus enclosed is white with a dark spot in the middle; behind, in the middle line and decreasing in size as they approach the apex, are several short transverse black bands. These markings are somewhat variable but the species is easily distinguished. Palpus pale with white hairs. Legs light brown with dark rings. Otherwise like ♂.

Habitat: Wisconsin, Michigan.

ATTUS IMPERIALIS Nov. Sp.

Plate III, figures 31, 31a.

♂. Total length 4 mm. Width of abdomen 2 mm.

Cephalothorax: length 2; width 1.7; height 1.2.

Legs 4.8, 3.1, 2.8, 4.2; patella and tibia of the first, 2; patella and tibia of the third, 9; patella and tibia of the fourth, 1.6; metatarsus and tarsus of the fourth, 1.3.

Cephalothorax moderately high, slightly convex, a little dilated behind dorsal eyes, with sides nearly vertical; cephalic part slightly inclined; thoracic part slanting gradually in the first two-thirds, then abruptly. Ocular area occupying a little less than one-half cephalothorax, one-third wider than long, wider behind than in front. First row of eyes very slightly curved; middle eyes sub-touching; lateral rather more than one-half as large as middle eyes, separated from them by two-thirds their own diameter; eyes of second row very slightly nearer lateral than dorsal eyes; dorsal as large as lateral eyes, further from each other than from lateral borders, forming a row as wide as the cephalothorax at that place. Clypeus one-fourth

as high as middle eyes, vertical; falces extending to inner edges of lateral eyes, as long as face, vertical, divergent; fang short, rather stout. Maxillæ parallel, enlarged and truncated at extremity, with projection on outer corner. Labium scarcely one-half as long as maxillæ, but little longer than wide, contracted at tip. Sternum less than one-half longer than wide, truncated in front, narrow behind. Anterior coxæ separated by more than width of labium. Legs, first and second stoutest, with femoral joints enlarged and compressed. Femoral, tibial and metatarsal spines on the four pairs; femoral spines weak; tibial and metatarsal spines of the first and second in two inferior rows, on the third and fourth very weak; on the metatarsi irregularly on the body of the articulation as well as in terminal circles.

Coloration: Cephalothorax dark reddish brown with a white band on each upper side, and, on the face, two snowy white bands which begin on each side between the middle and lateral eye and extend obliquely downward and backward to the cephalic margin. Parallel with these are two equally wide and white bands which cover the anterior faces of the falces. These bands make the appearance of the spider from in front very striking and characteristic. Abdomen reddish brown in the middle, with a longitudinal black band on each side; on each of these bands, near the apex, is a white dot, and below, the sides and base are encircled by a white band. Palpus brown with a ring of white hairs at the distal end of the femur. Mouthparts, sternum and venter dark brown. Coxæ light brown. Legs dark brown with femoral joints nearly black.

Habitat: California.

ICIUS LINEATUS C. K.

Plate I, figure 32. Plate III, figures 32, 32 a., 32 b.

Syn: 1848. MÆVIA *lineata* C. K., Die Arachn., XIV, p. 77.
1883. ATTUS *quadrilineatus* Peckham, Descr. new or little known Attidæ of U. S., p. 19.

♀. Total length 5.3 mm. Width of abdomen 2 mm.

Cephalothorax: length 2; width 1.5; height 8.

Legs 3.4, 2.4, 2.2, 3.9; patella and tibia of the first, 1.6; patella and tibia of the third, 8; patellia and tibia of the fourth, 1.5; metatarsus and tarsus of the fourth, 1.2.

Cephalothorax low, flat, a very little dilated behind dorsal eyes, with sides nearly vertical in front, rounded behind; cephalic part inclined; thoracic part falling slightly in first half, then more steeply. Ocular area occupying two-fifths of cephalothorax, one-fourth wider than long, very slightly wider behind. First eyes sub-touching, in a straight

row, all small, projecting, lateral about one-half as large as middle eyes; eyes of second row a little nearer the dorsal than the lateral eyes; dorsal a little smaller than lateral eyes, further from each other than from lateral borders, in a row as wide as the cephalothorax at that place. Clypeus one-fourth as high as middle eyes, vertical. Falces but little wider than the two middle eyes, a little longer than the face, vertical, parallel; fang very weak, maxillæ parallel, a little enlarged and blunt at extremity. Labium one-third as long as maxillæ, as wide as long, truncated. Sternum pointed in front and behind, nearly as wide as long. Anterior coxæ separated by a little less than width of labium. Legs of the first pair stoutest; femoral, tibial and metatarsal spines on the four pairs, metatarsi of the third and fourth with only terminal circles.

Coloration: Eye region black covered with yellowish hair, thoracic region testaceous with sparse yellow hair, lower margin black; abdomen (dry) blackish, with some yellow hairs; four slender lines of white hairs begin at the base; the two middle lines start from the same point; and separating a little pass out on each side of the middle to the spinnerets; the lateral lines extend along the sides from base to apex, and are not visible from above. Clypeus covered with white hairs; falces, mouthparts, sternum and coxæ all brown; palpi pale; legs brown, first pair darkest with black hairs; venter pale with irregular, dark, longitudinal lines.

Habitat: Pennnsylvania, Wisconsin, Georgia (Gentry Coll).

ICIUS PALMARUM HENTZ.

Plate I, figure 32. Plate III, figures 33, 33a.

Sym.: 1832. EPIBLEMUM *palmarum* H., Am. Jour. Sci. and Arts, art. 21, p. 108.
1845. " " id., Journal Bost. Soc. Nat. Hist., vol. V.
1875. " " id., Coll. Arachn. Writ. by N. M. Hintz, ed. by Burgess, Bost., p.71.
1883. " " Peckham, Descr. new or little known Attidæ of U. S., p. 28.

♂. Total length 5.5 mm. Width of abdomen 1.1 mm.

Cephalothorax: length 2.1; width 1.8; height 1.

Legs 6.1, 4.2, 3.5, 4.2; patella and tibia of the first, 2.9; patella and tibia of the third, 1.4; patella and tibia of the fourth, 1.7; metatarsus and tarsus of the fourth, 1.2.

♀. Total length 1.6 mm. Width of abdomen 1.2 mm.

Cephalothorax: length 1.6; width 1.4; height 8.

Legs 4.5, 2.7, 2.8, 3.5; patella and tibia of the first, 1.5; patella and tibia of the third, 1; patella and tibia of the fourth, 1.3; metatarsus and tarsus of the fourth, 1.

Cephalothorax moderately high, nearly plane, a very little dilated behind dorsal eyes, with sides nearly vertical in front and rounded behind; cephalic part very slightly inclined; thoracic part with the first half falling gradually and the second steeply. Ocular area occupying (♂) two fifths, (♀) less than two-fifths of cephalothorax, one-third wider than long, wider behind than in front. First row of eyes straight; middle eyes sub-touching; lateral one-half as large as middle eyes, and a little separated from them; eyes of second row a little nearer lateral than dorsal eyes; dorsal a little smaller than lateral eyes, further from each other than from lateral border, forming a row which is narrower than the cephalothorax at that place. Clypeus a little more than one-fourth as high as middle eyes. Falces compressed, parallel, extending to inner edges of lateral eyes, (♂) three times as long as face, horizontal, (♀) as long as face, vertical; fang (♂) as long as falx, (♀) short. Maxillæ long, enlarged at extremity, (♂) with projection at outer corner, and excavated for labium; (♀) rounded, not excavated. Labium two-thirds as long as maxillæ, nearly twice as long as wide, contracted and rounded at tip. Sternum oval, one-half longer than wide, scarcely projecting between anterior coxæ. Anterior coxæ separated by scarcely the width of the labium. Legs of the first pair much the longest and stoutest, especially in ♂, with femoral joints enlarged and compressed in both sexes; femoral, tibial and metatarsal spines on the four pairs, on metatarsi of the third and fourth, only in terminal circles.

Coloration: ♂. Cephalothorax bronze-brown, with short golden down, lighter in eye region; lower margin black; a wide white band passes around the clypeus and upper sides, just below the eyes, and just behind the dorsal eye, on each side, curves upward over the thorax, ending near the posterior margin; the eyes are surrounded with bright red hair. Abdomen bronze-brown, covered with golden down; there are white bands on the sides from base to apex, which do not meet at base, where there is a tuft of black hairs. Clypeus covered with long, snowy white hairs; falces dark rufus, with lines of white hairs on their outer edges; mouthparts almost black; sternum rufus; palpi and legs of the first pair (including coxæ) dark rufus; legs of the second, third and fourth (including coxæ), pale, tipped with black. Venter, rufus, edged with white. ♀. Cephalothorax, rufus, covered with white hairs, with lower margin black; there are two dark spots in the eye region, behind the middle anterior eyes, and some long black hairs outside the lateral eyes. Abdomen pale, covered with white hairs, and having a tuft of white hairs at base; there is a central, longitudinal, branching, rufus band, made up of many dots,

spots and lines, which is indistinctly visible through the white hairs. Clypeus with white hairs; falces, dark rufus; palpus, pale with three rufus bars, mouthparts very dark, sternum and coxæ, light rufus; legs of the first pair light rufus, the others pale, tipped with black. Venter covered with white hairs.

Habitat: New York, North Carolina, South Carolina, Alabama, Florida.

ICIUS MITRATUS HENTZ.

Plate I, figure 34. Plate III, figure 34a. Plate IV, figure 34.

Syn.: 1845. ATTUS *mitratus* (♂) H., Journal Bost. Soc. Nat. Hist., Vol. V.
1845. " *morigerus* (♀) id., ibid.
? 1848. MÆVIA *pallida*, C. K., Die Arachn, XIV, p. 79.
1875. ATTUS *mitratus* H., Coll. Arachn. Writings by N. M. Hentz ed. by Burgess, Boston, p. 68.
1875. " *morigerus* id., ibid., p. 69.

♂. Total length 4.7 mm. Width of abdomen 1 mm.

Cephalothorax: length 1.9; width 1.3; height .7.

Legs 5.6, 3.5, 3.2, 4; patella and tibia of the first, 2.2; patella and tibia of the third, 1.2; patella and tibia of the fourth, 1.6; metatarsus and tarsus of the fourth, 1.6.

♀. Total length 5 mm. Width of abdomen 1.5 mm.

Cephalothorax: length 2; width 1.4; height .8.

Legs 3.2, 3, 2.2, 3; patella and tibia of the first, 1.5; patella and tibia of the third, .9; patella and tibia of the fourth, 1.4; metatarsus and tarsus of the fourth, 1.4.

Cephalothorax rather low, slightly convex, a little dilated behind dorsal eyes, with sides nearly vertical in front, and rounded behind; cephalic part inclined; thoracic part falling gradually in the first half, then steeply. Ocular area occupying about two-fifths of cephalothorax, one-third wider than long, slightly wider behind than in front. First row of eyes straight; middle eyes sub-touching; lateral about one-half as large as middle eyes, separated from them by one-fourth their own diameter; eyes of second row half way between lateral and dorsal eyes; dorsal not quite so large as lateral eyes, further from each other than from lateral borders, forming a row slightly narrower than the cephalothorax at that place. Clypeus vertical, one-half as high as middle eyes. Falces a little wider than middle eyes, slightly longer than face, parallel, vertical; fang small. Maxillæ long, rounded and a little enlarged at the extremity; labium twice as long as wide, two thirds as long as maxillæ, a little rounded at tip, mouthparts longer and narrower in ♂ than in ♀. Sternum contracted in front, rounded behind, (♂) nearly twice as long as wide

(♀) one-half longer than wide. Anterior coxæ separated (♂) by width of labium, (♀) by scarcely so much. Legs of the first pair stoutest, and in ♂ very long. Femoral, tibial and metatarsal spines on the four pairs, on metatarsi of the third and fourth only in terminal circles.

Coloration: Cephalothorax reddish, covered with silvery down; eyes on black spots, a black line around margin, and (♀) two or three stout black hairs on each side below the eyes of the second row. Abdomen (♂) covered with white down with an encircling white band, and three, short, transverse dark bars on the dorsum; (♀) covered with down as in ♂, with three pairs of dark spots. Clypeus covered with white hairs which extend downward over the reddish falces. Mouth-parts and sternum reddish brown. Coxæ pale; palpi and legs pale tipped with black. Venter covered with silvery down.

Habitat: Wisconsin, Pennsylvania, North Carolina, Alabama, Georgia, Florida.

ICIUS PIRATICUS Nov. Sp.

Plate I, figure 35. Plate IV, figures 35, 35a.

♂. Total length 7 mm. Width of abdomen 2.2 mm.

Cephalothorax: length 3.9; width 2; height 1.3.

Legs 5.9, 3.5, 4.9, 5.2; patella and tibia of the first, 2.5; patella and tibia of the third, 1.8; patella and tibia of the fourth, 1.8; metatarsus and tarsus of the fourth, 1.6.

Cephalothorax low, flat, narrow in front, dilated behind dorsal eyes, with sides nearly vertical in front and rounded behind; cephalic part plane, slightly inclined; thoracic falling a very little in the first half, then more steeply. First row of eyes straight; middle eyes touching, lateral sub-touching, one-half as large, and placed plainly further back; eyes of second row a little nearer lateral than dorsal eyes, and very small; dorsal a little smaller than lateral eyes, further from each other than from lateral borders, forming a row as wide as cephalothorax at that place. Whole ocular area occupying a little more than one-third of cephalothorax, one-third wider than long, wider behind than in front. Clypeus inclined backward, one-half as high as middle eyes. Falces but little wider than the two middle eyes, one-fourth longer than face, vertical, parallel; fang very weak. Maxillæ long, parallel, a little enlarged and rounded at extremity. Labium two-thirds as long as maxillæ, twice as long as wide. Sternum not projecting between anterior coxæ, a little longer than wide, rounded. Anterior coxæ square, nearly touching. First leg with femur and tibia exceedingly stout, and metatarsus and tarsus very short; the other legs weak. Spinal armature as follows: Tibia of the

first, one short inferior spine; metatarsus of the first, two stout inferior spines; metatarsus of the second, two inferior not very stout spines; metatarsi of the third and fourth with only terminal circles.

Coloration: Cephalothorax with the entire upper surface covered with short white hairs, black on the sides, and white on the lower border; anterior middle eyes surrounded by reddish rings. Clypeus covered with short white and reddish hairs. Abdomen black with a wide central longitudinal white band, and the lower sides white. Falces black, with some short white hairs. Mouthparts black. Coxæ brown. Sternum black with white hairs. Venter covered with white hairs. Palpi brown with white hairs. Legs of the first pair black, and of the second, third and fourth, brown, all with white hairs which form heavy fringes on the undersides of the first legs.

Habitat: Texas.

ICIUS ALBOVITTATUS KEYSERLING.

Plate 1, figure 35a. Plate 4, figure 35d.

Syn.: 1885. WALA *albovittata* Keys., Neue Spinnen aus Amerika. VI, Verhandl. zool. bot. gesel. in Wien, p. 31 (517).

♂. Total length 5.2 mm. Width of abdomen 1.3 mm.

Cephalothorax: length 1.9; width 1.7.

Legs 6.4, 3.7, 3.5, 4.1; patella and tibia of the first, 2.7; patella and tibia of the third, 1.3; patella and tibia of the fourth 1.6; metatarsus and tarsus of the fourth, 1.3.

Cephalothorax low and flat, plainly wider in the middle, with rounded sides; cephalic part inclined forward. Quadrangle of eyes occupying almost one-half of the cephalothorax, a little more than one-third wider than long, wider behind than in front. First row of eyes a little bent. Middle eyes nearly touching; lateral one-half as large and separated from them by one-third their own diameter. Second row of eyes plainly nearer the first than the third row. Dorsal eyes as large as the lateral, further from each other than from the lateral borders, forming a row not quite so wide as cephalothorax at that place. Clypeus extremely low. Falces nearly as wide as first row of eyes, compressed from before behind, wider in middle than at base or extremity, a little inclined forward, diverging at the extremities; fang two-thirds as long as falx. Maxillæ slightly diverging, rather long, enlarged and truncated at extremity. Labium two-thirds as long as maxillæ, longer than wide, a little widest in middle, truncated. Sternum rounded, nearly as wide as long, projecting a very little between anterior coxæ. Anterior coxæ separated by less than width of labium. First legs much the longest and stoutest. Femoral and metatarsal spines on the four pairs, only in terminal circles on the third and fourth; tibial spines on the first and second.

Coloration: Cephalothorax red-brown covered above and on the upper sides with white hairs; lower sides brown; eyes and lower margin black; clypeus white; looked at from in front a dark line extends from each middle and from each lateral eye, backward and downward to the margin. Abdomen bronze brown encircled by a white band, below which is a dark brown band; lower sides brown: falces, mouthparts, sternum, coxæ and legs of first pair dark red-brown, excepting the proximal end of the metatarsus, and the tarsus which are yellow. The other coxæ and legs yellow tipped with black. Venter yellowish brown.

Habitat: North America.

PSEUDICIUS HARFORDII Nov. Sp.

Plate I, figures 36, 36a. Plate III, figure 36. Plate IV, figure 36a.

♂. Total length 6.3 mm. Width of abdomen 2.1 mm.

Cephalothorax: length 3; width 2.4; height 2.

Legs 6.1, 5.6, 5.3, 5.9; patella and tibia of the first, 2.6; patella and tibia of the third, 2.2; patella and tibia of the fourth, 2.5; metatarsus and tarsus of the fourth, 1.6.

♀. Total length 6.9 mm. Width of abdomen 2.7 mm.

Cephalothorax: length 3; width 2.4; height 1.7.

Legs 5.4, 7, 4.8, 5.6; patella and tibia of the first, 2.4; patella and tibia of the third, 2.2; patella and tibia of the fourth, 2.2; metatarsus and tarsus of the fourth, 1.8.

Cephalothorax moderately high, slightly convex, a little dilated in the middle, sides vertical in front, rounded behind; cephalic part inclined. Ocular area occupying two-fifths of the cephalothorax, one-fourth wider than long, equally wide in front and behind. Anterior eyes all small, in a straight row; middle eyes sub-touching; lateral one-half as large as middle eyes and scarcely separated from them; eyes of second row nearer lateral than dorsal eyes; dorsal as large as lateral eyes, further from each other than from lateral borders, forming a row not so wide as the cephalothorax at that place. Clypeus one-fourth as high as middle eyes, vertical. Falces wider than the two middle eyes, a little longer than the face, vertical, parallel; fang one-half as long as falx. Maxillæ narrow at base, enlarged at extremity, (♂) with point at outer corner, (♀) rounded, parallel. Labium oval (♂) one-half (♀) nearly two-thirds as long as maxillæ. Sternum contracted in front, one-third longer than wide. Anterior coxæ separated (♂) by more, (♀) by less than width of labium. Legs of the first and second pairs stoutest; femoral, tibial and metatarsal spines on the four pairs; stout and regular in two rows on tibiae and metatarsi of the first and second, less stout and regular on third and fourth; metatarsi of the fourth spined throughout their length.

Coloration. ♂. Cephalothorax light brown; a band of white hairs comes up from between the middle anterior eyes and joins a white spot which is found on the posterior cephalic part; on each upper side is a wide band of white hairs which extends from the anterior lateral eye, surrounding the dorsal eye, to the posterior margin; there is a white line around the lower margin; the entire face is covered with thick snowy white hairs, which grow from the sides toward the middle, surrounding the anterior eyes and growing downward on to the upper part of the falces; just behind and below the anterior lateral eyes are some small scattering tufts of black hairs. Abdomen light golden brown, encircled by a wide band of white hairs. Falces (excepting the white hairs at the upper edge) and mouthparts dark reddish brown. Sternum, coxæ and venter light brown. Legs all light brown excepting the last three joints of the first pair which are dark reddish brown; all the legs tipped with black. ♀. Cephalothorax light brown covered with short white hairs, which are easily rubbed off, but usually show a white band coming up from between the middle anterior eyes. Abdomen covered with gray hairs and fine red dots. Venter covered with gray hairs. Mouthparts pale. Legs pale (excepting first pair which is light brown) all tipped with black. Face and other parts as in male. In some cases the male retains the coloration of the female.

This species bears a strong general resemblance to Icius albo-vittatus Keys.

Habitat: California.

SADALA NOV. GEN.

Cephalothorax rather low and nearly flat, contracted slightly in front and behind, one-fourth longer than wide, and a very little wider than the third row of eyes. Cephalic part occupies two-fifths of the cephalothorax; the thoracic part begins to slant near its posterior border, and is rounded behind. Quadrangle of eyes nearly twice as wide as long, and equally wide in front and behind. First row of eyes nearly straight, middle very nearly touching, and three times as large as the lateral, from which they are just separated. Second row of eyes small and plainly nearer (two-fifths) the anterior lateral. Dorsal eyes as large as lateral, and much further from each other than from the lateral borders. Clypeus very low (one-fifth to one-eighth the height of anterior middle eyes). Sternum oval, a little longer than wide, projecting between the coxæ of the first pair, which are separated by the width of the labium. Labium less than half as long as the maxillæ, and as wide as long. Falces short (as long as the face) but little longer than wide. Legs 1, 4, 2, 3. First stoutest, second next. The patella with tibia of the third shorter than patella with tibia of the

fourth. Metatarsus with tarsus of the fourth shorter than patella with tibia. Femoral, tibial and metatarsal spines on the four pairs. Metatarsi of the fourth spined to the base. Abdomen long and slender.

Sadala is near *Icius* E. S., but differs in having the quadrangle of eyes nearly twice as wide as long; middle eyes three times as large as the anterior lateral; quadrangle of eyes equally wide in front and behind; legs 1, 4, 2, 3; metatarsi of the third and fourth spined throughout their length.

SADALA DISTINCTA Nov. Sp.

Plate I, figure 70. Plate VI, figures 76, 76a.

♂. Total length 5.3 mm. Width of abdomen 1.1 mm.

Cephalothorax: length 2; width 1.5; height 6.

Legs 4.6, 3.6, 3.1, 3.9; patella and tibia of the first, 2.2; patella and tibia of the third, 1; patella and tibia of the fourth, 1.6; metatarsus and tarsus of the fourth, 1.2.

Cephalothorax not high, slightly convex, contracted in front and behind, with sides rounded, more widely behind than in front; cephalic part plane, not inclined; thoracic part with first three-fifths level. Ocular area occupying two-fifths of cephalothorax, one-third wider than long, very slightly wider in front than behind. First row of eyes nearly straight; middle eyes prominent, touching; lateral only one-third as large as middle eyes, and slightly separated from them; eyes of second row very small, a little nearer lateral than dorsal eyes; dorsal as large as lateral eyes, much further from each other than from lateral borders, forming a row very nearly as wide as cephalothorax at that place. Clypeus retreating, one-eighth as high as middle eyes. Falces as wide as the two middle eyes, scarcely longer than face, length and width about equal, parallel, slightly inclined backward; fang very small. Maxillæ enlarged and truncated at extremity, parallel. Labium one-half as long as maxillæ, as wide as long, rounded. Sternum oval, about twice as long as wide. Anterior coxæ separated by width of labium. Legs of the first pair stoutest, second next; these two pairs with femoral joints compressed; femoral tibial and metatarsal spines on the four pairs; metatarsi of the fourth, armed throughout their length. Palpus with a tibial apophysis.

Coloration: Cephalothorax clear light-reddish brown; a black band includes the first and second rows of eyes; the dorsal eyes are placed upon black spots, and there are two dark spots on the posterior cephalic part; on each side a white line extends from the lateral eyes on to the anterior thoracic part, passing below the small median and the

dorsal eye; near the termination of this line, at the point at which the thoracic part begins to slant downward, there arises a slightly oblique white line which passes downward to the border. The lower margin is dark brown. Clypeus brown. The lower anterior face of the abdomen is black; above this is a curved white band which ends, on each side, in an oblique bar. The anterior dorsum is umber brown; in front of the middle are two black spots, separated by a line of brown; a little behind these is one large black spot which is surrounded by white. There is a second pair of oblique white bars, on the sides, at this point of the abdomen. The posterior end of the abdomen is white, with one or two transverse bands of light brown. The entire dorsum is sparsely covered with long yellowish hairs. Falces black. Mouthparts, palpi, and coxæ of the first and second, brown; coxæ of the third and fourth, pale, each with a black spot. Sternum black. Legs of the first and second, dark brown; of the third, femur dark brown, other joints lighter; of the fourth, light-brown or pale; patella and tibia of the third and fourth, with black lines on both anterior and posterior faces. Venter black.

Habitat: Mexico.

ERIS OCTAVUS HENTZ.

Plate I, figure 37, Plate III, figure 37.

Syn.: 1845. ATTUS *octavus* H., Journal Bost. Soc. Nat. Hist., Vol. V.
1875. ATTUS *octavus* id., Coll. Arachn. Writ. by N. M. Hentz. Ed. by Burgess, Boston, p. 70.

♀. Total length 4.2 mm.

Cephalothorax: length 1.8; width 1.5; height 1.

Legs 4.2, 3, 3, 3.9; patella and tibia of the first, 1.5; patella and tibia of the third, 1.2; patella and tibia of the fourth, 1.4; metatarsus and tarsus of the fourth, 1.1.

Cephalothorax a little wider at the dorsal eyes, with sides nearly vertical in front, rounded in the thoracic part, and truncated behind. Ocular area one-fourth wider than long, wider behind than in front; anterior row of eyes straight; lateral more than one-half middle eyes, separated from them by one-half their own diameter; eyes of second row half way between lateral and dorsal eyes; dorsal eyes further from each other than from lateral borders. Clypeus one-fifth as high as middle eyes. Falces extending in width to inner edges of lateral eyes, as long as face, parallel, vertical. Maxillæ rather long, a little enlarged and rounded at tip, parallel; labium one-half as long as maxillæ, as wide as long, contracted and rounded at tip. Sternum one-half longer than wide, narrow at both ends, truncated in

front. Anterior coxæ separated by scarcely the width of the labium. First pair of legs stoutest. Femoral, tibial and metatarsal spines on the four pairs; the metatarsi of the fourth spined throughout their length.

Coloration: Cephalothorax and abdomen light rufus, brown, or yellowish, covered with short white hairs; cephalothorax with the eyes on black spots; abdomen with four pairs of black spots on the posterior part, in two converging longitudial lines; all the other parts light brown with short white hairs, the legs being tipped with black.

Habitat: New York, Alabama, North Carolina, Georgia.

ERIS (?) BARBIPES Nov. Sp.

Plate IV, figures 38, 38a.

♀. Total length 6.8 mm. Width of abdomen 2.7 mm.

Cephalothorax: length, 2.4; width, 1.9; height 1.2.

Legs 4.8, 3.6, 4.5, 5.3; patella and tibia of the first, 2.1; patella and tibia of the third, 1.7; patella and tibia of the fourth, 2.3; metatarsus and tarsus of the fourth, 1.9.

Cephalothorax moderately high, slightly convex, very slightly dilated in the middle, with sides nearly vertical; cephalic part a little inclined; thoracic part falling gradually in the first two-thirds, then steeply. Ocular area occupying one-half cephalothorax, one-third wider than long, plainly wider behind than in frout. Anterior eyes all subtouching, in a straight row; middle twice as large as lateral eyes; eyes of second row nearly twice as far from dorsal as from lateral eyes; dorsal as large as lateral eyes, further from each other than from lateral borders, forming a row as wide as cephalothorax at that place. Clypeus vertical, one-fourth as high as middle eyes. Falces nearly as wide as first row of eyes, twice as long as face, vertical, parallel; fang short. Maxillæ rather long, parallel, enlarged and rounded at extremity. Labium more than one-half as long as maxillae, twice as long as wide, pointed at tip. Sternum about twice as long as wide, slightly contracted in front and behind. Anterior coxæ separated by less than width of labium. Legs of the first pair much stoutest; tibia especially enlarged with fringe of hairs; third and fourth slender; femoral, tibial and metatarsal spines on the four pairs; metatarsi of the fourth spined throughout their length.

Coloration: Cephalothorax black, with cephalic and anterior thoracic parts covered with short greenish hairs, and a white band around lower margin. Abdomen black with white basal band, covered with short scalelike slightly iridescent greenish hairs. Clypeus, falces,

mouthparts and sternum black. Coxæ dark brown. Venter covered with hairs as above. Palpi light, covered with short white hairs. Legs of the first pair black, excepting metatarsi and tarsi which are light brown; other legs brown, lighter toward extremities, with some short white hairs.

Habitat: Mexico.

ERIS NERVOSUS Nov. Sp.

Plate I, figure 39. Plate III, figure 39.

♀. Total length 4 mm. Width of abdomen 1.5 mm.

Cephalothorax: length 1.6; width 1.4; height .7.

Legs 4, 3.2, 2.9, 3.7; patella and tibia of the first, 1.3; patella and tibia of the third, .9; patella and tibia of the fourth, 1.3; metatarsus and tarsus of the fourth, 1.

Cephalothorax not high, nearly plane, a little dilated opposite dorsal eyes, with sides nearly vertical in front, and somewhat rounded behind; cephalic part very little inclined; thoracic part sloping from just behind dorsal eyes. Ocular area occupying nearly three-fifths of cephalothorax, one-fourth wider than long, wider behind than in front. Anterior eyes small, in a straight row, slightly separated from each other; middle scarcely twice as large as lateral; eyes of second row twice as far from dorsal as from lateral eyes; dorsal as large as lateral eyes, further from each other than from lateral borders, forming a row as wide as cephalothorax at that place. Clypeus one-half as high as middle eyes, a little inclined backwards. Falces extending to inner edges of lateral eyes, a little longer than the face, nearly square, parallel, a little inclined backward, fang weak. Maxillæ diverging a little, enlarged and rounded at extremity. Labium one-half as long as maxillæ, a little longer than wide, rounded. Sternum nearly round. Anterior coxæ separated by scarcely the width of the labium. Legs of the first pair stoutest, with femoral joints enlarged and compressed, and patella and tibia much stouter than metatarsus and tarsus; weak femoral spines on first, second and third; stout tibial and metatarsal spines on the first, and weak spines on the corresponding joints of the second.

Coloration: Cephalothorax black. Clypeus black with a few long white hairs. Abdomen dark reddish brown with some very short white hairs, three rather indistinct, oblique black bands on each side of dorsum, and two white chevrons at apex. Falces and mouthparts dark brown. Sternum and coxæ light brown. Venter dark reddish brown with short gray hairs. Palpi and legs light brown, the legs tipped with black.

Habitat: New York.

HASARIUS HOYI PECKHAM.

Plate I, figures 40, 40a. Plate IV, figure 40, 40a.

Syn.: 1883. ATTUS *hoyi* (♂) P., Descrip. of new or little known Attidæ, p.7.

1883 " *pinus* (♀) id., ibid., p. 20.

♂ Total length 5.2 mm. Width of abdomen 1.8 mm.

Cephalothorax: length 2.3; width 1.9; height 1.6.

Legs 5.2, 4, 5.2, 4.9; patella and tibia of the first, 2; patella and tibia of the third, 1.7; patella and tibia of the fourth, 1.9; metatarsus and tarsus of the fourth, 1.6.

♀ Total length 5.9 mm. Width of abdomen 2.2 mm.

Cephalothorax: length 2.5; width 2; height 1.7.

Legs 4.6, 4.2, 5, 4.8; patella and tibia of the first, 2.2; patella and tibia of the third, 1.9; patella and tibia of the fourth, 2.1; metatarsus and tarsus of the fourth, 1.9.

Cephalothorax rather high, plane, slightly dilated behind dorsal eyes, with sides nearly vertical in front, rounded behind; cephalic part inclined (more strongly in ♂ than in ♀); thoracic part falling but little in the first two-thirds, then steeply. Ocular area occupying two-fifths of cephalothorax, one-third wider than long, and almost imperceptibly wider in front than behind. First row of eyes straight; middle eyes sub-touching; lateral more than one-half as large as middle eyes, separated from them by by one-third their own diameter; eyes of second row half way between dorsal and lateral eyes; dorsal a little smaller than lateral eyes, further from each other than from lateral borders, forming a row scarcely narrower than the cephalothorax at that place. Clypeus (♂) vertical, one-third, (♀) inclined, one-fifth as high as middle eyes. Falces extending to the inner edges of lateral eyes, but little longer than face, vertical, parallel; fang weak. Maxillæ parallel, short, slightly enlarged and rounded at extremity; labium one-half as long as maxillæ, but little longer than wide, a little contracted and blunt at tip. Sternum oval, one-half longer than wide. Anterior coxæ separated by width of labium. Legs of the first and second pairs stoutest; third longer than fourth by greater length of femur, femoral, tibial and metatarsal spines on the four pairs; on metatarsi of the fourth throughout their length.

Coloration: ♂. Ocular and anterior thoracic region rufus a little mixed with black; posterior thoracic region black; a white band on each side, beginning at or near the base passes forward to the anterior lateral eyes, and joining these, a white band crosses above the anterior eyes; the sides below the white bands are velvety black; the anterior eyes are surrounded by hairs which are white excepting just between the eyes, where they are red; looked at from above this

gives the appearance of three minute red tufts. Clypeus black with white hairs. Abdomen black with an encircling white band and a central, longitudinal, rufus band which varies greatly in length and breadth, upon which are some variable white marks, which usually consist of two short, oblique lines near the base, a triangle in the middle, and a series of chevrons near the apex. Falces dark testaceous with sparse short white hairs; maxillæ and labium brown; sternum dark with black and white hairs; venter black with rufus hairs, palpi and legs barred with black and rufus excepting the proximal ends of the femoral joints which are pale. ♀. Cephalothorax covered with brown, black and rufus hairs, with a grayish band behind dorsal eyes, which passes downward and forward on the sides to the lateral eyes; clypeus covered with white hairs. Abdomen rufus or light brown with a grayish basal band, behind which is a curved black band; there are several other curved black bands near the apex,and a central, longitudinal black line. Falces, mouthparts and sternum brown; palpus pale with hair which is light brown excepting at the extremity, where it is white; legs, first pair dark; the others brown with black hairs.

Habitat: Pennsylvania, New York, Wisconsin.

Since describing *hoyi* and *pinus* as two species (1883) we have satisfied ourselves that *pinus* is the female of *hoyi*.

HABROCESTUM (E. SIMON), 1876.

Cephalothorax rather short, one-fourth to one-third longer than wide, moderately high to very high: thoracic part often convex, but slightly dilated on the sides, which are somewhat rounded, only a third the longer. Cephalic part a little convex, inclined, limited by a faint depression. Quadrangle of eyes one-third wider than long, and equally wide in front and behind, or a little wider behind. Anterior row of eyes rather unequal — middle about twice lateral — middle but little separated, lateral by not more than one-third their diameter, forming a line straight or slightly curved upward. Second row small, and nearly half way between the first and third rows. Dorsal eyes equal to or a little larger or smaller than the anterior lateral, forming a row about as wide as the cephalothorax at that place, and almost equally distant from each other and from the lateral borders. Clypeus varies from one-half to two-thirds the large middle eyes. Sternum one-half longer than wide, often truncated in front and contracted behind, produced between the anterior coxæ, which are separated by a little more or less than the width of labium at its base. Labium as wide as long[1] and less than one-half the maxillæ. Falces weak

[1] This is true at least in the American species.

and as long as the face. Maxillæ enlarged and rounded or truncated at extremity. Legs 3, 4, 1, 2, in both sexes. The posterior pairs long, both absolutely and relatively. The first and second pairs the stoutest. All the legs spined. Femur, patella and tibia of the third much longer than the same articulations in the fourth pair. Tarsus and metatarsus of the fourth nearly equal to the patella and tibia.

This genus differs from *Saitis* E. S.— to which it is closely related — in having the quadrangle of the eyes never wider in front; usually the clypeus is more than one-half the middle eyes; the third pair of legs is longer than the fourth. In *Saitis* the third and fourth pairs are equal or almost equal.

HABROCESTUM CORONATUM HENTZ.

Syn.: 1845. ATTUS *corontus H.*, Journal Bost. Soc. Nat. Hist., vol. V.
1875. ATTUS *corontus, id.*, Coll. Arachn. Writ. by N. M. Hentz. Ed. by Burgess, Boston, p. 64.

♂. juv. Total length 5.5 mm. Width of abdomen 2 mm.
Cephalothorax: length 2.9; width 2.
Legs, 3.8, 2.4, 5.2, 4.8.
Cephalothorax high. Ocular area equally wide in front and behind. First row of eyes straight; middle eyes subtouching; lateral a little more than one-half as large as middle eyes, separated from them by one-fourth of their own diameter; eyes of second row half way between lateral and dorsal eyes; dorsal as large as lateral eyes. Clypeus two-thirds as high as middle eyes, vertical. Anterior coxæ separated by more than width of labium.

Coloration: Cephalothorax black with some white hairs over the anterior eyes, and two curved longitudinal white bands on the thoracic part. Clypeus bright red, sometimes covered with white hairs. Abdomen black, with three transverse curved white bands, one at the base, the second in front of, and the third behind the middle of the dorsum, the second and third sometimes interrupted in the middle line, and having one or two white chevrons between them; behind the third curved band is a large central white spot, and on each side of the apex is a short longitudinal white band. Falces dark brown. Mouth-parts pale drab. Sternum, coxæ and venter light brown with white hairs. Palpi and legs brown with black hairs.

Habitat: Pennsylvania, Alabama, Iowa.

HABROCESTUM CŒCATUM HENTZ.

Plate I, figure 42. Plate IV, figures 42, 42a, 42b.

Syn.: 1845. ATTUS *cœcatus* H., Journal Bost. Soc. Nat. Hist., Vol. V.
1875. " " id., Coll. Arachn. Writ. by N. M. Hentz. Ed. by Burgess, Boston, p. 65.

♀. Total length 4.3 mm. Width of abdomen 1.7 mm.
Cephalothorax: length 2; width 1.8; height .9.
Legs, 3.6, 2.9, 4.4, 4.

Cephalothorax moderately high; cephalic part much inclined. Ocular area wider behind than in front. First row of eyes straight; middle eyes sub-touching; lateral less than one-half as large as middle eyes, separated from them by one-third their own diameter; eyes of second row half way between lateral and dorsal eyes; dorsal eyes a little smaller than lateral eyes. Clypeus retreating, two thirds as high as middle eyes. Anterior coxæ separated by fully the width of the labium.

Coloration: Cephalothorax black, with gray hairs above anterior eyes. Clypeus bright red. Abdomen black, more or less covered with whitish hairs, with a curved transverse white band, behind which are a white, diamond-shaped spot, two short, longitudinal, white bands on the sides, and two white dots near the apex. Falces, mouthparts, sternum, coxæ and venter brown, all with white hairs excepting the mouthparts. Femur of the first leg black, with a short brush of black hairs at distal end; patella and tibia covered with white hairs; metatarsus and tarsus brown; other legs dark brown with some white hairs; patella of the third with an elevation on the upper surface at the distal end; tibia of the third with a short projection which extends over the metatarsus.

Distinguished from *H. cornatum* by the projection on the tibia of the third leg.

Habitat: Pennsylvania, New York, Alabama.

HABROCESTUM VIRIDIPES HENTZ.

Plate I, figure 43. Plate IV, figures 43, 43a.

Syn.: 1845. ATTUS *viridipes* H. Jour. Bost. Soc. of Nat. Hist., Vol. V.
1875. " " id., Coll. Arachn. Writ. by N. M. Hentz. Ed. by Burgess, Boston, p. 66.

♂. Total length 4.8 mm. Width of abdomen 1.8 mm.
Cephalothorax: length 2.3; width 1.8; height 1.4.

Legs 3.5, 3.3, 5.2, 4.6; patella and tibia of the first, 1.8; patella and tibia of third, 2; patella and tibia of the fourth, 1.7; metatarsus and tarsus of the fourth, 1.9.

♀ Total length 5.8 mm. Width of abdomen 3 mm.

Cephalothorax: length 2.3; width 2; height 1.6.

Legs 3.9, 3.7, 4.8, 4.2; patella and tibia of the first, 1.6; patella and tibia of the third, 2; patella and tibia of the fourth, 1.8; metatarsus and tarsus of the fourth, 1.8.

Cephalothorax moderately high. Ocular area equally wide in front and behind. First row straight, all the eyes sub-touching; lateral less than one-half as large as middle eyes; eyes of second row half way between lateral and dorsal eyes; dorsal as large as lateral eyes. Clypeus nearly two-thirds as high as middle eyes, vertical. Anterior coxæ separated by width of labium.

Coloration: Cephalothorax black with two wide longitudinal bands of grayish hairs which arise on the posterior thoracic region and extending forward, surround the dorsal eyes, and meet just in front of them, thus occupying nearly the whole of the cephalic part. Clypeus covered with white hairs. Abdomen blackish with a basal band, a scalloped band which encircles the posterior two-thirds of the dorsum, and a central spot of a yellowish white color. The spot and the inner side of the encircling band are edged with deep black. The other parts are of a lighter or darker brown color, the sternum being sometimes much darker than the coxæ.

Habitat: Texas, South Corolina.

HABROCESTUM PEREGRINUM PECKHAM.

Plate I, figure 44. Plate IV, figure 44, 44a, 44b.

Syn.: 1883. ATTUS *peregrinum* P., Descr. new or little known Attidæ of U. S., p. 17.

♂. Total length 5.3 mm. Width of abdomen 1.9 mm.

Cephalothorax: length 2.9; width 2; height 1.2.

Legs 5.3, 4.5, 6.4, 5.6; patella and tibia of the first, 2.6; patella and tibia of the third, 2.4; patella and tibia of the fourth, 1.7; metatarsus and tarsus of the fourth, 1.9.

Cephalothorax high, especially behind; cephalic part much inclined. Ocular area a little wider behind than in front. Anterior eyes all small, in a straight row; middle eyes sub-touching; lateral a little more than one-half as wide as middle eyes, separated from them by one-third their own diameter; eyes of second row slightly nearer lateral than dorsal eyes; dorsal a little larger than lateral eyes. Clypeus two-thirds

as high as middle eyes, retreating. Two unusually stout spines on tibia of the first pair; patella of the third widening toward distal end where it projects over tibia; this widened portion bears a short pale spine which projects over tibia, just behind which, on the anterior face is a small black dot. Anterior coxæ separated by width of labium.

Coloration: Ground color of cephalothorax dark brown or black; upper surface of cephalic part covered with short fawn-colored hairs, bordered behind by a scalloped white band; thorax with two wide white bands which extend from dorsal eyes to posterior border; a wide white band extends entirely around the lower border, and below this is a narrow black line. Abdomen snowy white on sides and middle of dorsum, with two velvety black longitudinal bands extending throughout its length. Clypeus covered with thick, long, white hairs. Underparts and legs lighter or darker brown, well covered with white hairs.

This species is close to *H. Copardum* Hentz, but is distinguished from it by the apophysis on the third leg; this apophysis and the spines on the tibia of the first leg vary considerably in stoutness.

Habitat: New York, Connecticut.

HABROCESTUM CRISTATUM HENTZ.

Plate I, figure 45. Plate IV, figure 45.

Syn.: 1845. ATTUS *cristatum* H., Journal Bost. Soc. Nat. Hist., Vol. V.
1875. " " id., Coll. Arachn. Writ. by N. M. Hentz. Ed. by Burgess, Boston, p. 67.

♀. Total length 6.6 mm. Width of abdomen 2.2 mm.

Cephalothorax: length 3.4; width 2.4; height 1.2.

Legs 4.8, 4.5, 6.8, 6.1; patella and tibia of the first, 2; patella and tibia of the third, 2.8; patella and tibia of the fourth, 2.2; metatarsus and tarsus of the fourth, 2.2.

Cephalothorax moderately high. Ocular area wider behind than in front. First row of eyes slightly covered; middle eyes sub-touching; lateral a little less than one-half as large as middle eyes, separated from them by one-third their own diameter; eyes of second row a little nearer dorsal than lateral eyes; dorsal as large as lateral eyes. Clypeus nearly two-thirds as high as middle eyes, retreating. Anterior coxæ separated by less than width of labium.

Coloration: Cephalothorax dark, nearly covered with grayish hair. Clypeus covered with white hairs. Abdomen covered with grayish rufus hair with two spots on the anterior part, a slender band which curves upward from the sides over the middle part, and a small ring

on the posterior region black. Falces and mouthparts dark brown. Sternum and coxæ light brown. Legs brownish rufus. Venter covered with grayish hair.

Habitat: New York, Connecticut, Alabama.

HABROCESTUM AURATUM HENTZ.

Plate I, figure 46a. Plate IV, figures 46, 46a, 46b.

Syn: 1845. *Attus auratum H.*, Jour. Bost. Soc. Nat. Hist., Vol. V.
1875. " " Coll. Arachn. Writ. by N. M. Hentz, Ed. by Burgess, Boston, p. 66.

♂. Total length 5 mm. Width of abdomen 1.9 mm.

Cephalothorax: length 2.8: width 1.8; height 1.

Legs 4, 3.8, 5.8, 4.2; patella and tibia of the first, 1.8; patella and tibia of the third, 2.1; patella and tibta of the fourth, 1.6; metatarsus and tarsus of the fourth, 1.6.

♀. Total length 6.4 mm. Width of abdomen 3 mm.

Cephalothorax: length 3.2; width 2.2; height 1.1.

Legs 4.5, 4.3, 6.2, 4.8; patella and tibia of the first, 2; patella and tibia of the third, 2.4; patella and tibia of the fourth, 1.9; metatarsus and tarsus of the fourth, 1.9.

Cephalothorax moderately high, ♀ less convex than ♂; cephalic part in clined more in ♂ than in ♀. Ocular area equally wide in front and behind. First row of eyes straight, middle eyes sub-touching; lateral a little less than one-half middle eyes, separated from them by (♀) one-third their own diameter, (♂) scarcely so much; eyes of second row very slightly nearer lateral than dorsal eyes, dorsal as large as lateral-eyes. Clypeus two-thirds as high as middle eyes, retreating. Anterior coxæ separated by scarcely the width of the labium.

Coloration: ♂. Cephalothorax covered with short black hairs which are intermingled with others of a yellowish brown color, these latter being by far the most numerous in the eye region and giving to that part its predominating tint. Three white bands come up on to the caput from the interspaces in the first row of eyes; the central one of these terminates behind the middle of the eye region; the lateral ones pass just above the small median eyes, surround the dorsal eyes and on the thoracic part curve first toward, and then away from each other, terminating at the posterior border. Around the lower margin is a black line, and just above this a band of white. Abdomen black encircled by a wide white band and having a central longitudiual white band which ends a little in front of the spinnerets. Clypeus and falces blackish brown, clypeus sparsely covered with

short, and falces with long white hairs. Sternum black, and coxæ light yellowish brown, both being covered, not very thickly, with white hairs. Venter gray, covered thickly with a mixture of black and white hairs. Legs and palpi medium brown with many white scales and some black hairs. Femur of the first with a distinct tuft of stiff black hair on the under side. Patella of the first with a small, and tibia of the first with a much larger tuft of stiff black hairs on the upper surface. ♀. Cephalothorax covered with gray hairs. Abdomen covered with gray hairs, with a basal band, two oblique bands on each side, two spots near the apex, and a central line of chevrons white. Falces reddish brown. Underparts, legs and palpi covered with short white hairs.

This species is close to *H. peregrinum* but the two species are distinguished from each other by the differences in the first and third pairs of legs. *Habitat:* New York, South Carolina, Georgia.

HABROCESTUM HIRSUTUM. Nov. Sp.

Plate IV, figures 47, 47a.

♂. Total length 5.8 mm. Width of abdomen 2 mm.

Cephalothorax: length 3; width 1.7; height 1.4.

Legs 4.9, 3.9, 5.8, 5.4; patella and tibia of the first, 1.7; patella and tibia of the third, 2; patella and tibia of the fourth, 1.7; metatarsus and tarsus of the fourth, 1.9.

Cephalothorax high, slightly convex behind, dilated in the middle, with sides rounded more widely behind than in front; cephalic part plane, not inclined; thoracic sloping slightly in the first half, then more steeply. Ocular area occupying two-fifths of cephalothorax, not quite one-third wider than long, wider behind than in front. First row of eyes straight; middle eyes sub-touching; lateral less than one-half as large as middle eyes and a little separated from them; eyes of second row half way between lateral and dorsal eyes; dorsal as large as lateral eyes, further from each other than from lateral borders, forming a row as wide as cephalothorax at that place. Clypeus inclined backward, nearly as high as middle eyes. Falces as wide as the two middle eyes, a little shorter than face, parallel, inclined backward; fang rather long. Maxillæ parallel, short, square, truncated. Labium as wide as long, very short, rounded. Sternum oblong oval, nearly twice as long as wide, narrow. Anterior coxæ separated by width of labium; coxæ of the fourth touching. Legs of the first pair stoutest; femoral, tibial and metatarsal spines on the four pairs, and patellary spines on first and fourth; metatarsi of the fourth spined throughout their length.

Coloration: Cephalothorax black, probably originally covered with short white and red hairs, with a band of white hairs and some long black hairs above the anterior eyes. Clypeus covered with red hairs. Abdomen and venter covered with short whitish brown hairs. Falces reddish brown. Mouthparts, sternum, coxæ and palpi brown. Legs brown with light hairs, first pair darkest with a fringe of stout black hairs on the tibia.

Habitat: Oregon.

HABROCESTUM SPLENDENS PECKHAM.

Plate I, figure 48. Plate V, figures 48, 48a.

Syn.: 1883. ATTUS *splendens* P., Descr. new or little known Attidæ of U. S., p. 4.

1885. PELLENES *nigroceps* Keyserling, Neue Spinnen aus Amerika, VI, Verhandlungen zoologisch-botanischen Gesellschaft., p. 26 (512).

♂. Total length 6.5 mm. Width of abdomen 2.2 mm.

Cephalothorax: length 3; width 2.2; height 1.6.

Legs 3.9, 3.7, 4.9, 4.5; patella and tibia of the first, 1.9; patella and tibia of the third, 1.9; patella and tibia of the fourth, 1.8; metatarsus and tarsus of the fourth, 1.5.

♀. Total length 7.7 mm. Width of abdomen 2.9 mm.

Cephalothorax: length 3.1; width 2.5; height 1.3.

Legs 5.7, 4.5, 7.2, 5.8; patella and tibia of the first, 2; patella and tibia of the third, 3; patella and tibia of the fourth, 1.8; metatarsus and tarsus of the fourth, 1.9.

Cephalothorax high and convex, a little dilated opposite dorsal eyes, sides nearly vertical in front, rounded behind; posterior margin truncated; Ocular area occupying two-fifths of cephalothorax, one-third wider than long, a little wider behind than in front; anterior row of eyes straight; middle eyes slightly separated; lateral less than one-half as large as middle eyes, separated from them by one-third their own diameter; eyes of second row half way between dorsal and lateral eyes; dorsal as large as lateral eyes, further from each other than from lateral borders, forming a row a little narrower than the cephalothorax at that place. Clypeus (♂) nearly as high, (♀) one-half as high as middle eyes. Falces extending to inner edges of lateral eyes, but little longer than the face, vertical, parallel; fang short. Maxillæ parallel, widely separated, enlarged and blunt at extremity; labium as wide as long, a little less than one-half as long as maxillæ, blunt. Sternum narrowed at both ends, truncated in front, rounded behind; (♂) twice as long as wide, (♀) relatively shorter. Anterior

coxæ separated (♂) by scarcely width of labium, (♀) by more than width of labium. Legs of the first and second pairs stoutest; femoral, patellary, tibial and metatarsal spines on the four pairs; ♂ with spines on trochanters; metatarsi of the fourth spined throughout their length.

Coloration: ♂. Cephalothorax covered with dark,but highly iridescent scales; under alcohol two whitish testaceous spots appear just behind dorsal eyes; lower margin black; some upright black hairs on anterior part of eye region. Abdomen bright iridescent red, lighter around margin, purplish on dorsum, four indented dots near base, and sometimes a whitish basal band; whole abdomen covered with sparse black hairs; spinnerets black; under alcohol the base and a curved oblique band on each side appear black, and the dorsum dark iridescent green with a short longitudinal red band, narrowest in the middle. Clypeus iridescent; falces dark reddish brown with long white hairs on their inner edges; maxillæ white at extremities and on inner edges. otherwise reddish; labium reddish tipped with white; sternum testaceous, darker than coxæ, with white hairs; coxæ covered with white hairs; palpi and legs almost black; venter iridescent red with two indistinct darker longitudinal bands. ♀. Cephalothorax rufus, or more rarely black in the eye region, with a transverse black band between the dorsal eyes; posterior to this is a scalloped white or rufus band which curves forward in the middle; behind the scalloped band the thoracic part is black; the sides are black above, and white below; the margin has a narrow black line between two white lines. Abdomen velvety black, with basal, central, and lateral white bands, which are sometimes tinted with salmon-color. Clypeus covered with white hairs; falces reddish, with white hairs on anterior face; maxillæ and labium brown; palpi and legs varied with rufus and black, with white hairs; venter covered with whitish and rufus hairs.

Count Keyserling has kindly sent us a specimen of his *Pellenes nigroceps* which we find to be identical with *H. splendens.* The female of this species is extremely variable, especially in the abdominal markings.

Habitat: Wisconsin, Massachusetts.

HABROCESTUM OREGONENSE Nov. Sp.

Plate V, figures 49, 49a.

♂. Total length 5.8 mm. Width of abdomen 1.9 mm.

Cephalothorax: length 2.5; width 1.6; height 1.

Legs 5, 3.8, 6, 5.5; patella and tibia of the first, 2.3; patella and tibia of the third, 2.5; patella and tibia of the fourth, 2; metatarsus and tarsus of of the fourth, 2.

Cephalothorax high, convex, a little dilated behind dorsal eyes, with sides slightly concave in front and a little rounded (nearly vertical) behind; cephalic part inclined; thoracic falling abruptly from a little way behind dorsal eyes. Ocular area occupying more than two-fifths of cephalothorax, one-third wider than long, equally wide in front and behind. Anterior eyes rather small, in a very slightly curved row; middle eyes sub-touching, scarcely twice as large as the lateral, which are scarcely separated from them; eyes of second row a little nearer dorsal than lateral eyes; dorsal a little smaller than lateral eyes, further from each other than from lateral borders, forming a row as wide as cephalothorax at that place. Clypeus retreating, one-half as high as middle eyes. Falces but little wider than the two middle eyes, square, not long, parallel, a little inclined backward; fang extremely small. Maxillæ parallel, very small, wider and rounded at extremity. Labium small, a little more than one-third as long as maxillæ, as wide as long, rounded. Sternum nearly round. Anterior coxæ separated by more than width of labium at base. Legs of the first pair much the stoutest, with tibia nearly as wide as long, much enlarged in all directions, with fringes of stout hairs; patella and tibia also enlarged with some stout hairs; long and slender femoral, tibial and metatarsal spines on the four pairs, and patellary spines on the third and fourth; metatarsi of the fourth spined throughout their length.

Coloration: Cephalothorax dark colored, nearly covered with bright iridescent red hairs, with which, on the cephalic part, some long black hairs are intermixed; lower border with a black line between two white lines; anterior eyes surrounded by white rings. Abdomen, venter, clypeus, falces, palpus and legs all covered with iridescent red hair. Mouthparts, sternum and coxæ very dark brown, with some short, white hairs.

Habitat: Oregon.

SAITIS PULEX HENTZ.

Plate I, figures 50, 50a. Plate V, figures 50, 50a.

Syn.: 1845. ATTUS *pulex* H., Journal Bost. Soc. Nat. Hist., Vol. V.

1846.? EUOPHRYS *offuscata* C. K., Die Arachn., XIII, p. 218.

1875. ATTUS *pulex* id., Coll. Arachn. Writ. by N. M. Hentz. Ed. by Burgess, Boston, 65.

1885. CYRBA *pulex* Keyserling, Neue Spinnen aus Amerika, VI, Verhandlungen zoologisch-botanischen Gesellschaft, p. 23 (509).

♂. Total length 4 mm. Width of abdomen 1.4 mm.

Cephalothorax: length 2.5; width 1.1; height 1.2.

Legs 2.5, 2.5, 4, 4; patella and tibia of the first, 1.3; patella and tibia of the third, 1.5; patella and tibia of the fourth, 1.5; metatarsus and tarsus of the fourth, 1.5.

♀. Total length 4.5 mm. Width of abdomen 2.2 mm.

Cephalothorax: length 2.5; width 1.4; height 1.3.

Legs 3, 3, 4.4, 4.5; patella and tibia of the first, 1.3; patella and tibia of the third, 1.6; patella and tibia of the fourth, 1.6; metatarsus and tarsus of the fourth, 1.6.

Cephalothorax high and convex, a little dilated behind dorsal eyes, sides nearly vertical in front, and rounded behind, more widely in ♂ than in ♀; cephalic part inclined; thoracic part slanting a little from dorsal eyes, and dropping abruptly near posterior border. Ocular area occupying two-fifths of cephalothorax, one-fourth wider than long, slightly wider in front than behind. Anterior eyes on a projecting ridge, all sub-touching, in a slightly curved row; lateral about one-half as large as middle eyes; eyes of second row half way between lateral and dorsal eyes; dorsal a little smaller than lateral eyes, further from each other than from lateral borders, forming a row narrower than the cephalothorax at that place. Clypeus retreating, one-third as high as middle eyes. Falces but little wider than the two middle eyes, about as long as face, inclined backward, parallel; fang extremely weak. Maxillæ parallel, but little enlarged at extremity, (♂) almost truncated, (♀) blunt, inner edge vertical. Labium one-half as long as maxillæ, narrow and hollowed at base, enlarged in middle, contracted at tip (♂) nearly twice as long as wide, (♀) but little longer than wide. Sternum one-half longer than wide, truncated in front, narrow and rounded behind. Anterior coxæ separated by more than the width of the labium. Legs all slender; femoral, tibial and metatarsal spines on all the legs, and patellery spines on the third and the fourth; metatarsi of the fourth spined throughout their length. Femoral joints of the first and second not enlarged, but compressed, especially in ♂.

Coloration: Cephalothorax dark brown; eye region black; central thoracic region covered with gray and rufus hairs; lower margin black; reddish rings around anterior eyes. Abdomen dark brown or black; a white central band arises at base, and enlarging and then again narrowing, reaches the central point of the dorsum; posterior to this two short, oblique, white bands form a chevron whose apex, pointing forward, touches the extremity of the central band; near the apex are several small white chevrons; there is a white band on each side. The white dorsal markings in the ♀ are sometimes broken up as in figure 50; usually they resemble those of the ♂. Clypeus, falces, mouthparts, sternum and venter brown, glabrous. Palpi and legs

sometimes dark brown, sometimes pale with brown rings. Coxæ pale.

Habitat: New York, Pennsylvania, Wisconsin, Iowa, Tennessee, and Alabama.

PROSTHECLINA CAMBRIDGII Nov. Sp.

Plate I, figure 51. Plate V, figures 51, 51a.

♂. Total length 5.2 mm. Width of abdomen 2 mm.

Cephalothorax: length 2.7; width 2; height 1.9.

Legs 6.4, 5, 6, 6; patella and tibia of the first, 2.5; patella and tibia of the third, 2.1; patella and tibia of the fourth, 2; metatarsus and tarsus 2.

♀. Total length 5.8; width of abdomen 2.5.

Cephalothorax: length 2.5; width 1.8; height 1.7.

Legs 4.8, 4.5, 5.3, 5.7; patella and tibia of the first, 2; patella and tibia of the third, 2; patella and tibia of the fourth, 2; metatarsus and tarsus of the fourth, 1.9.

Cephalothorax rather high, convex, slightly dilated behind dorsal eyes, sides vertical; cephalic part inclined; ocular area occupying a little less than one-half cephalothorax, less than one-fourth wider than long, a little wider in front than behind. Anterior row of eyes a little curved; the four eyes sub-touching; lateral more than one-half as large as middle eyes; eyes of second row halfway between lateral and dorsal eyes; dorsal smaller than lateral eyes, nearer to each other than to lateral borders, in a row scarcely narrower than the cephalothorax at that place. Clypeus vertical, one-third as high as middle eyes. Falces extending to inner edges of lateral eyes, but little longer than face, vertical, parallel, fang short, weak. Maxillæ parallel, enlarged and rounded at tip; labium nearly as wide as long, a little more than one-half as long as maxillæ, rounded. Sternum nearly round, truncated in front. Anterior coxæ separated by a little more than the width of labium. Legs of the first stoutest, of the second next; femoral, tibial and metatarsal spines on the four pairs, throughout the length of the articulation on metatarsi of the fourth.

Coloration: Cephalothorax black, with some gray hairs above the anterior eyes, a white parenthesis on the anterior part of the thoracic region, and white bands on the lower sides; abdomen greyish rufus with four black spots; clypeus, falces, and sternum black with short white hairs; mouthparts and coxæ rufus; legs of the first, dark, nearly black, of the second, third, and fourth, varied with black, white and rufus, palpi rufus with black tarsi; venter covered with gray hairs.

This species agrees with the genus *Prostheclina* Keys., excepting that the relative length of the legs in the ♂ is 1, 3, 4, 2; not 1, 4, 3, 2.

Habitat: Florida.

ASTIA VITTATA HENTZ.

Plate I, figure 52, 52a. Plate V, figure 52, 52a.

Syn.: 1845. ATTUS *vittatus* H., Jour. Bost. Soc. Nat. Hist., Vol. V.
1845. " *niger* (♂) id., ibid.
1846. PLEXIPPUS *undatus* C. K., Die Arachn., XIII, p. 123.
1848. MAEVIA *pencillata* (♂) C. K., Die Arachn., XIV, p. 69.
1875. ATTUS *vittatus* H., Coll. Arachn. Writ. by N. M. Hentz. Ed. by Burgess, Boston, p. 64.
1875. " *niger* (♂) id., ibid., p. 63.

♂. Total length 7 mm. Width of abdomen 2.1 mm.

Cephalothorax: length 3; width 1.9; height 1.7.

Legs 5.4, 5, 5.1, 6.3; patella and tibia of the first, 2.8; patella and tibia of the third, 2.3; patella and tibia of the fourth, 2.8; metatarsus and tarsus of the fourth, 2.8.

♂. Total length 8 mm. Width of abdomen 2.8.

Cephalothorax: length 3.4; width 2.4; height 2.

Legs 5.7, 5.6, 6.3, 6.9; patella and tibia of the first. 3.6; patella and tibia of the third, 2.9; patella and tibia of the fourth, 3.2; metatarsus and tarsus of the fourth, 3.

Cephalothorax moderately high, nearly plane, dilated behind dorsal eyes, with sides nearly vertical in front, and rounded behind; cephalic part a little inclined forward; thoracic part slanting but little in the first half, steeply in the second. Ocular area occupying two-fifths of the cephalothorax, one-third wider than long, a little wider in front than behind; anterior eyes projecting forward, in a straight row; middle eyes touching; lateral one half as large as middle eyes, and slightly separated from them; eyes of second row half way between lateral and dorsal eyes; dorsal a little smaller than lateral eyes, further from each other than from the lateral borders, forming a row not quite so wide as the cephalothorax at that place. Clypeus (♂) one-half, (♀) one-third as high as middle eyes, slightly inclined. Falces (♀) but little wider than middle eyes, one-half longer than face, vertical, parallel; ♂ weaker and shorter than in ♀; fang weak. Maxillæ parallel, enlarged and rounded at extremity; labium a little longer than wide, one-half as long as maxillæ, contracted and blunt at tip. Sternum nearly twice as long as wide, scarcely projecting between anterior coxæ; anterior coxæ almost touching. (♀) first legs stoutest with femur, patella and tibia enlarged; (♂ ♀) with spines on trochanters, femora, patellæ, tibiæ and metatarsi of the four pairs, those on the femora numerous at the distal ends; (♂) legs and spines weaker than in ♀.

Coloration: ♂. Presenting two distinct varieties; the first has the thoracic part of the cephalothorax light brown and glabrous with a cen-

tral, longitudinal, black line, while the eye region is black with some short white hairs; the abdomen is mottled with black, red and white, sometimes with alternate white and red chevrons on the central region; clypeus white; falces, mouthparts, sternum and coxæ pale; venter covered with short white hairs; legs white with black spots and spines, and underneath on the fermoral joints, characteristic, oblique, black bars; the second variety (*niger*) has the cephalothorax black, with a pale spot, divided by a longitudinal, black line, in the central thoracic region, and, on the posterior part of the eye region, forming a transverse row, three long tufts of black hairs; abdomen black; clypeus, palpi, falces, sternum, mouthparts, venter and sometimes coxæ very dark or black; legs pale, with a yellowish tint in comparison with the white legs of the first variety, tipped with black. Intermediate between these varieties is one which is nearly as dark as *niger*, with pale legs, but without the cephalic tufts. So unlike in general appearance are the extreme forms that they were placed by C. Koch in two different genera (*Plexippus undatus*, Die Arachniden, xiii, fig. 1183, and *Maevia pencillata*, Die Arachniden, xiv, fig. 1325). As this is an extremely common species we have compared large numbers of them, but have never found the tufts present in the first variety, which most resembles the ♀. ♀. Cephalothorax light brown in thoracic part, black in eye region, with short white and red hairs; abdomen white on sides and central dorsum, with two longitudinal bright red bands; in rubbed specimens the central region and sides are pale flecked and striped with reddish, and the bands are dark red; clypeus, falces, mouthparts, sternum, coxæ, palpi and legs pale; venter covered with short white hairs.

Habitat: United States.

ASTIA (?) MOROSA Nov. Sp.

Plate I, figure 53. Plate V, figures 53, 53a.

♂. Total length 5 mm. Width of abdomen 2.1 mm.

Cephalothorax: length 2.4; width 1.8; height 1.3.

Legs 5.4, 4, 5.1, 5.3; patella and tibia of the first, 2.5; patella and tibia of the third, 2.2; patella and tibia of the fourth, 2.2; metatarsus and tarsus of the fourth, 1.9.

♀. Total length 6 mm. Width of abdomen 3.2 mm.

Cephalothorax: length 2.9; width 2; height 1.7.

Legs 5.8, 4.9, 6.3, 6.8; patella and tibia of the first, 2.4; patella and tibia of the third, 2.3; patella and tibia of the fourth, 2.6; metatarsus and tarsus of the fourth, 2.4.

Cephalothorax high, especially behind, convex, a little dilated in the middle, with sides vertical in front and a little rounded behind; cephalic part plainly inclined; thoracic part slanting quite abruptly from a little behind dorsal eyes, the cephalothorax being evidently highest in the middle. Ocular area occupying a little more than one-third of cephalothorax, one-third wider than long, a little wider in front than behind. First row of eyes straight; middle eyes touching, lateral more than one-half as large as middle eyes, (♀) touching them, (♂) separated from them by one-fourth their own diameter; eyes of second row half way between dorsal and lateral eyes; dorsal as large as lateral eyes, (♂) equally distant from each other and lateral borders, (♀) a little nearer each other. Clypeus (♂) one-fourth, (♀) one-fifth as high as middle eyes, (♂) retreating, (♀) vertical. Falces as wide as the two middle eyes, (♂) a little longer than face, (♀) as long as face, parallel, inclined backward; fang weak, maxillæ parallel, narrow at base, enlarged at extremity, and truncated. Labium as wide as long, less than one-half as long as maxillæ, contracted at tip. Sternum nearly twice as long as wide, rounded in front, pointed behind. Anterior coxæ separated (♀) by width of labium, (♂) more widely. Legs (♂) of the first very slightly stouter than the others, (♀) equally stout; femoral, tibial and metatarsal spines on the four pairs; (♂) with patellary spines; metatarsi of the fourth spined throughout their length.

Coloration: ♂. Cephalothorax pale in thoracic part, much darker in eye region, probably originally covered with short white hairs; marginal line black; middle anterior eyes surrounded by rings of white hairs. Clypeus reddish brown. Abdomen with a black central longitudinal line over the anterior part of the dorsum, which bifurcates posteriorly, thus bounding a large triangular pale spot; this spot is limited behind by some irregular black marks; the sides are pale with black dots and spots. Falces, mouthparts, sternum and coxæ all light brown. Venter pale with black dots. Legs brown with black rings and tips, the color being considerably darker on the last three joints of the first leg. ♀. Cephalothorax and abdomen black, almost covered with mixed red and gray hairs; on the abdomen these hairs are thick at the base, and form three wide longitudinal bands, one central and two lateral, over the dorsum, and a large trirngular spot behind the middle point; near the apex, on each side, are two white dots, the anterior larger and a little external to the posterior. Clypeus covered with short white hairs. Falces dark brown. Mouthparts, sternum and coxæ light brown. Legs and palpi brown with darker rings. Venter pale with irregular black dots.

Habitat: California.

MÆVIA CALIFORNICA Nov. Sp.

Plate V, figures 54, 54a.

♂. Total length 6 mm.

Cephalothorax: length 2.1; width 1.5; height 1.2.

Legs 5.7, 4.5, 4.5, 5.5; patella and tibia of the first, 2.3; patella and tibia of the third 1.9; patella and tibia of the fourth, 2.1; metatarsus and tarsus of the fourth, 2.

Cephalothorax high, convex; sides nearly parallel, almost vertical in front, and rounded behind; cephalic part very slightly inclined; thoracic slanting from just behind dorsal eyes. Ocular area occupying two-fifths of cephalothorax, one-third wider than long, equally wide in front and behind. Anterior eyes small, sub-touching, in a slightly curved row; middle scarcely twice as large as lateral eyes; eyes of second row a little nearer lateral than dorsal eyes; dorsal as large as lateral eyes, nearer to each other than to lateral borders, forming a row about as wide as cephalothorax at that place. Clypeus one-half as high as middle eyes, slightly inclined backward. Falces nearly as wide as first row of eyes, one and one-half times as long as face, parallel, slightly inclined backward; fang moderately long. Maxillæ parallel, enlarged at the extremity, with projection at outer corner. Labium less than one-half as long as maxillæ, as wide as long, rounded. Sternum plane, a little longer than wide, truncated in front, rounded behind. Anterior coxæ separated by width of labium. Legs of the first and second pairs stoutest with fermoral joints compressed; tibial and metatarsal spines (stoutest on first and second), on the four pairs; metatarsi of the fourth spined throughout their length.

Coloration: Entire spider black, excepting the tarsi and sometimes the distal ends of the metatarsi, which are pale.

Habitat: California.

CYTÆA (?) MINUTA Nov. Sp.

Plate I, figure 55. Plate V, figures 55, 55a.

♂. Total length 4.8 mm. Width of abdomen 1.6 mm.

Cephalothorax: length 2.1; width 1.6; height 1.1.

Legs 4, 3, 3. 6, 3; cephalothorax much longer than patella and tibia of the first; patella and tibia of the third longer than patella and tibia of the fourth; patella and tibia of the fourth and metatarsus and tarsus of the fourth equal.

♀. Total length 5 mm. Width of abdomen 1.6 mm.

Cephalothorax: length 2.3; width 1.5; height 1.1.

Legs 3.8, 3.5, 4.1, 4.8; cephalothorax much longer than patella and tibia of the first; patella and tibia of the third shorter than patella and tibia of the fourth; patella and tibia of the fourth and metatarsus and tarsus of the fourth equal.

Cephalothorax low, flat, a little contracted behind, with sides nearly vertical in front, and slightly rounded posteriorly; cephalic part not inclined; thoracic part level in the first half, then falling steeply. Ocular area occupying a little less than two-fifths of cephalothorax, one-fourth wider than long, equally wide in front and behind. Anterior eyes sub-touching, in a straight row; middle scarcely twice as large as lateral eyes; eyes of second row halfway between lateral and dorsal eyes; dorsal as large as lateral eyes, further from each other, nearly as wide as cephalothorax at that place. Clypeus scarcely perceptible. Falces as wide as first row of eyes, a little longer than face, vertical, parallel; fang short and weak. Maxillæ parallel, enlarged at extremity, (♂) with small projection at outer corner. Labium more than one-half as long as maxillæ, longer than wide, contracted and rounded at tip. Sternum one-fourth longer than wide, truncated in front. Anterior coxæ separated by width of labium. Legs nearly equally stout; femoral, tibial and metatarsal spines on the four pairs; on tibiæ and metatarsi of the third and fourth more above than below; metatarsi of the fourth spined throughout their length.

Coloration. ♂. Cephalothorax with thoracic part dark brown, and cephalic part with short rufus and long black hairs, three reddish tufts appearing between the anterior eyes, which are surrounded by red rings; there are three longitudinal white bands, one central, running from the anterior eyes to the posterior border, and one on each lower side above the black marginal line. Clypeus covered with yellowish white hairs. Abdomen dark brown or blackish with a central longitudinal abbreviated white line not reaching the middle, and, on each side, a longitudinal white line which reaches beyond the middle, posterior to which are three transverse curved white marks, one behind the other. Falces and mouthparts dark brown. Palpi covered with thick white hairs above, and sparse black hairs below. Sternum, coxæ and legs light brown, the legs with darker rings, and tipped with black. Venter covered with white hairs. ♂. Cephalothorax resembling that of ♂ but with a greater tendency to reddish color in the eye region, with the white of the bands not so clear, and with the central band extending only from the dorsal eyes to the posterior border. Abdomen dark brown or blackish, with a wide, notched, central, longitudinal white band extending nearly to the apex, just behind which, on each side, is a short, oblique, white line; there is a white transverse band at the apex, and, on each side of the dorsum, a longitudinal row of four or

five white spots. Palpi pale with white hairs. Other parts like ♂ excepting that the legs are paler.

Habitat: California.

CYRBA TÆNIOLA HENTZ.

Plate I, figure 56. Plate IV, figure 56a. Plate V, figures 56, 56b.

Syn.: 1845. ATTUS *tæniola* H., Journal Bost. Soc. Nat. Hist. Vol. V.
1875. " " id., Coll. Arachn. Writ. by N. M. Hentz. Ed. by Burgess, Boston, p. 56.

♂. Total length 4 mm. Width of abdomen 1.8 mm.

Cephalothorax: length 2.2; width 1.8; height 1.2.

Legs 4.8, 3.6, 3.6, 5.1; patella and tibia of the first, 2; patella and tibia of the third, 1.3; patella and tibia of the fourth, 2.2; metatarsus and tarsus of the fourth, 1.7.

♀. Total length 6.7 mm. Width of abdomen 2.2 mm.

Cephalothorax: length 2.7; width 2.1; height 1.2.

Legs 4.4, 3.6, 3.7, 4.9; patella and tibia of the first, 2; patella and tibia of third, 1.6; patella and tibia of the fourth, 2.3; metatarsus and tarsus of the fourth, 1.7.

Cephalothorax low, flat, sides nearly parallel, and almost vertical in front, rounded behind; cephalic part a little inclined; thoracic part almost level in anterior three-fourths, then falling abruptly. Ocular area occupying a little less than one-half cephalothorax, one-third wider than long, equally wide in front and behind. Anterior eyes projecting, in a straight row; middle eyes touching; lateral one-half as large, and scarcely separated from middle eyes; eyes of second row nearer lateral than dorsal eyes; dorsal not so large as lateral eyes, further from each other than from lateral borders, forming a row nearly as wide as cephalothorax at that place. Clypeus vertical, one-fifth as high as middle eyes. Falces but little wider than the two middle eyes, one-half longer than face, vertical, parallel; fang weak and short. Maxillæ widely separated, parallel, long, a little enlarged and rounded at extremity. Labium one-half as long as maxillæ, a little longer than wide. (♂) truncated, narrower than in ♀, (♀) blunt. Sternum not projecting between anterior coxæ, rounded in front and behind, (♂) one-fourth longer than wide, (♀) twice as long as wide. Anterior coxæ nearly touching. Legs of the first much the stoutest, with femoral joints compressed; tibial and metatarsal spines on the four pairs; metatarsi of the fourth spined throughout their length.

Coloration: Cephalothorax black, with lower margin white. Abdomen black with two longitudinal rows of white dots or abbreviated lines. Clypeus, falces, mouthparts, sternum, coxæ, palpi and venter black.

Legs of the first and second pairs black, excepting metatarsi and tarsi which are light rufus; third and fourth light rufus, excepting femoral joints which are black.

Habitat: Pennsylvania, South Carolina, Alabama, Georgia, Florida, Wisconsin.

EPIBLEMUM SCENICUM CLERCK.

Plate 1, figure 57. Plate IV, figure 57.

Syn.: 1757. ARANEUS *scenicus Cl.*, Sv. Spindl., p. 117 (saltem ad. part.)
1758. ARANEA *scenica* Linn., Syst. Nat., Ed. 10, I, p. 623, (saltem ad part.)
1778. " *albo-fasciata* De Geer, Mem., vii, p. 287 (saltem ad part.)
1805. ATTUS *scenicus* Walck. Tabl. d. Aran., p. 24 (ad part).
1806. SALTICUS *scenicus* Latr., Gen. Crust. et Ins., I, p. 123 (saltem ad part).
1825. ATTUS *scenicus*, Walck., Faune Franc., Arachn., p. 44 (ad part).
182?. " " Hahn. Monogr. Aran., 4, Pl. I, figs. A, B.
1831. SALTICUS " *id.*, Die Arachn, I. p. 57 (saltem ad part.)
1832. EPIBLEMUM *faustum* Hentz, Am. Jour. Science and Arts, xxi, p. 108.
1833. ATTUS *scenicus* Sund., Sv. Spindl. Beskrifn., in Vet.-Akad. Handl. f. 1832, p. 202.
1837. CALLIETHERA *scenica* C. Koch, Uebers. d, Arachn-Syst., I, p. 31.
1837. " *histrionica* id., ibid.
1846. " " id., Die Arachn., xiii, p. 42.
1846. " *scenica* id., ibid, p. 37.
1846. " *anlica* id., ibid, p. 51.
1846. SALTICUS *propinquus* Lucus, Expl. Alg., Ar., p. 162.
1846. " *albovittatus* id., ibid, p. 164.
1846. EPIBLEMUM *faustum* Hentz, Journal Bost. Soc. Nat. Hist., v. p. 367.
1856. CALLIETHERA *histrionica* Thorell; Rec. crit. Aran., p. 68.
1856. " *scenica* id., ibid (ad part).
1861. SALTICUS *scenicus* Blackw., Spid. of Gr. Brit., I, p. 47.
1869. CALLIETHERUS *histrionicus* Sim., Monogr. d. Att. d'Eur., p. 650 (184).
1870. EPIBLEMUM *histrionicum* Thorcel. on Eur. Spid., p. 211.
1872. EPIBLEMUM *scenicum* id., ibid, II, p. 360.
1876. CALLIETHERA *sceinca Sim*, Arachnides de France, III, p. 64.

1880. EPIBLEMUM *scenicum* Workman, Irish Spid., Belfast Nat. Hist. Soc., p. 16.

1883. " " Campbell, Spid. of Hoddesdon, Hertfordshire Nat. Hist. Soc., p. 276.

1884. CALLIETHERA *scenica Sim*,., Arachnides de Miranda de Ebro, Soc. Esp. de Hist. Nat.. xiii, 114 (2).

1885. " " *id.*, Arachnides de Tunisie, p. 3.

♂. Total length 4.9 mm. Width of abdomen 1.8 mm.
Cephalothorax: length 2.5; width 1.9; height 1.1.
Legs 3.9, 2.7, 2.7, 3.2.
♀. Total length 5.5 mm. Width of abdomen 1.8 mm.
Cephalothorax: length 2.2; width 1.3; height 1.2.
Legs 3.8, 2.5, 3.2, 4.

Cephalothorax moderately high, slightly convex, a little dilated behind dorsal eyes, with sides almost vertical in front, and rounded behind; cephalic part slightly inclined; thoracic part falling gradually until the last one-third and then steeply. Ocular area occupying a little more than one-third of the cephalothorax, one-third wider than long, equally wide in front and behind. First row of eyes straight; middle eyes touching; lateral one-half as large as middle eyes, and scarcely separated from them; eyes of second row halfway between lateral and dorsal eyes; dorsal nearly as large as lateral eyes, further from each other than from lateral border, forming a row scarcely narrower than the cephalothorax at that place. Clypeus vertical, one-fourth as high as middle eyes. Falces not quite so wide as first row of eyes, (♂) four times as long as face, horizontal, diverging, with two teeth on distal third; fang long; (♀) one and one-half as long as face, vertical, parallel, fang short. Maxillæ long, (♂) truncated at tip, slightly diverging; (♀) rounded, parallel. Labium a little longer than wide, slightly contracted at tip, (♂) less than one-half, (♀) more than one-half maxillæ. Sternum rounded behind, truncated in front, about twice as long as wide, relatively wider in ♂ than in ♀. Anterior coxæ separated by width of labium. Legs of the first pair a little the stoutest; metatarsal spines on the third and fourth in terminal circles; (♀) femoral and tibial spines as well.

Coloration: Cephalothorax dark brown, with clypeus and lower border white, and two white spots in the anterior thoracic region. Abdomen rufus, with a basal band and two slightly oblique bands on each side of dorsum white. Falces dark brown, mouthparts and sternum blackish, with white hairs; coxæ brown. Palpi and legs light brown, with darker rings. Venter blackish, with white hairs.

Habitat: North America, Europe, North Africa.

ADMESTINA Nov. Gen.

Cephalothorax low and plane, a *little* widest opposite the middle of thoracic part, more contracted in front than behind, less than twice as long as wide, the cephalic and thoracic parts not separated. The thoracic part is twice as long as the cephalic part, and is truncated behind. In front the sides are nearly vertical while behind they are rounded. Quadrangle of eyes much wider — nearly twice — than long, and very little wider behind. Anterior row a little curved upward, the middle twice the lateral and near together; the lateral separated from the middle by almost one-half their own diameter. Second row small and placed two-fifths from the anterior lateral. Dorsal eyes slightly larger than lateral and as wide as the cephalothorax at that place; plainly further from each other than from the lateral borders. Clypeus one-half as high as the large middle eyes. Sternum nearly oval, not produced between the coxæ of the first pair, which are nearly touching. Maxillæ enlarged and blunt at the extremity. Labium as wide as long, and less than half of the maxillæ. Falces weak, wide as middle eyes, and a little longer than the face, vertical, parallel. Legs 4, 1, 3, 2; first pair stoutest; the tibia and patella of the first much shorter than the cephalothorax. Tibia and patella of the third shorter than tibia and patella of the fourth, the latter longer than the tarsus and metatarsus of the fourth. Legs without spines except on metatarsus of the first pair. Abdomen rather long and narrow. Nearest *Hyctia* Simon, but differs in the much greater width of the quadrangle of the eyes, in the quadrangle being wider behind, not parallel; and the relative length of the legs. The sternum is not narrow.

ADMESTINA WHEELERII Nov. Sp.

Plate I, figure 58. Plate V, figure 58.

♂. Total length 3.7 mm. Width of abdomen 1.2 mm.

Cephalothorax: length 1.6; width 1; height 6.

Legs 2.3, 1.9, 2.1, 2.7; patella and tibia of the first, 1; patella and tibia of the third, 8; patella and tibia of the fourth, 1; metatarsus and tarsus of the fourth, 8.

Coloration: Cephalothorax and clypeus black. Abdomen pale, with a central longitudinal branching dark band. Falces and mouthparts dark brown. Sternum black. Coxæ dark brown, excepting those of the fourth pair which are pale. Venter pale with a wide, central dark band. Palpus brown. Legs pale with dark rings.

Habitat: Wisconsin.

HYCTIA PIKEI Nov. Sp.

Plate I, figure 59. Plate IV, figure 59a. Plate V, figure 59.

♂. Total length 8.2 mm. Width of abdomen 1.1 mm.

Cephalothorax: length 2.9; width 1.8; height .9.

Legs 7.1, 4, 3.6, 4.6; patella and tibia of the first, 3.1; patella and tibia of the third, 1.5; patella and tibia of the fourth, 1.9; metatarsus and tarsus of the fourth, 1.4.

♀. Total length 8.5 mm. Width of abdomen 1.1.

Cephalothorax: length 2.9; width 1.8; height .9.

Legs 6.3, 3.3, 3, 5; patella and tibia of the first, 2.8; patella and tibia of the third, 1.3; patella and tibia of the fourth, 2; metatarsus and tarsus of the fourth, 1.4.

Cephalothorax very low, flat, long and slender, being nearly twice as long as wide, contracted in front, the dilation beginning just in front of the dorsal eyes and increasing in the thoracic part; cephalic part plane, not inclined, sides vertical; thoracic part with sides a little rounded, sloping gradually from dorsal eyes to posterior margin. Ocular area occupying about one-third of cephalothorax, very little wider than long, equally wide in front and behind; anterior row of eyes distinctly visible from above, straight; lateral about one-third as large as middle eyes, scarcely separated from them; middle eyes touching; eyes of second row very small, halfway between lateral and dorsal eyes; dorsal smaller than lateral eyes, much farther from each other than from lateral borders, forming a row which is as wide as the cephalothorax at that place. Clypeus only a line. Falces extending in width to inner edges of lateral eyes, but little longer than face, vertical, parallel. Maxillæ parallel, long, narrow, truncated. Labium more than one-half as long as maxillæ, longer than wide, pointed. Sternum very long and narrow. Anterior coxæ (♂) very close together but separated by anterior end of sternum; (♀) separated by width of labium. Coxæ of fourth pair touching; second and third pairs of coxæ separated from each other by a considerable interval. First pair of legs much the longest and stoutest, with trochanters visible from above, and tibiæ enlarged. Femoral, tibial and metatarsal spines on the four pairs, and one small patellary spine on the first; spines on the tibiæ and metatarsi of the first very long and stout, on the third and fourth exceedingly weak and far apart. Abdomen, very long, slender and low.

Coloration: ♂. Cephalothorax very dark brown, blackish on eye region with some black hairs, and yellowish on the sides, with a black marginal line; abdomen with a wide, central, longitudinal, black band from base to apex, and some stiff black hairs at base; on each side below the black band, a band of whitish hairs; falces dark brown;

mouthparts light brown; sternum, coxæ and venter yellowish, first pair of legs dark brown, the others yellowish tipped with black. ♀. Much like ♂ but lighter in color; cephalothorax showing a slender, central, longitudinal black line from the middle of the cephalic to nearly the middle of the thoracic part; the central band on abdomen dark brown, the sides lighter, but not white; first legs darker than the others but lighter than in ♂.

Easily distinguished, as the abdomen is more than three time as long as wide.

Habitat: New York, South Carolina, Georgia, Florida.

MARPTUSA FAMILIARIS HENTZ.

Plate I, figure 60. Plate IV, figure 60a. Plate V, figure 60.

Syn.: 1845. ATTUS *familiaris*, H., Journal Bost. Soc. Nat. Hist., Vol. V.
1846. MARPISSA *undata*, C. K., Die Arachn. XIII, p. 60.
1846. " *conspersa* (♂) id., ibid., XIII, p. 61.
1846. " *varia*, id., ibid., XIII, p. 69.
1875. ATTUS *familiaris*, H., Coll. Arachn. Writ. by N. M. Hentz, Ed. by Burgess, Boston, p. 56.

♂. Total length 9.5 mm. Width of abdomen 2.9 mm.

Cephalothorax: length 4.4; width 3.2; height 2.1.

Legs 10.6, 8.4, 8.2, 10; patella and tibia of the first, 4.4; patella and tibia of the third, 2.9; patella and tibia of the fourth, 3.3; metatarsus and tarsus of the fourth, 2.9.

♀. Total length 10.5 mm. Width of abdomen 3.5 mm.

Cephalothorax: length 4.5; width 3.5; height 1.8.

Legs 9, 7.7, 7.7, 9.1; patella and tibia of the first, 3.8; patella and tibia of the third, 3; patella and tibia of the fourth, 4; metatarsus and tarsus of the fourth, 2.9.

Ocular area occupying less than one-third of cephalothorax, nearly twice as wide as long, and equally wide in front and behind. Anterior eyes in a scarcely curved row, the lateral less than one-half as large as the middle eyes, and separated from them by one-half their own diameter, while the middle eyes are slightly separated from each other; eyes of the second row halfway between lateral and dorsal eyes; dorsal a little smaller than lateral eyes, placed (♂) a little, (♀) plainly further from each other than from the lateral borders, forming a row much narrower than the cephalothorax at that place. Clypeus nearly vertical, rather less than one-half as high as middle eyes. Falces extending, in width, to the inner edges of the lateral eyes; one-half longer than face, parallel, vertical; fang short. Maxillæ parallel, enlarged and rounded at extremity. Labium a little

more than one-half as long as maxillæ, as wide as long; contracted and blunt at tip. Sternum one-half longer than wide, a little narrower in front than behind. Anterior coxæ separated by scarcely the width of the labium. Femoral, tibial and metatarsal joints of the first and second pairs enlarged. Metatarsi and tarsi slender; femoral, tibial and metatarsal spines on the four pairs; metatarsi of the fourth spined throughout their length.

Coloration: Cephalothorax rufus, darkest in the eye region, with short dense gray hairs, and a few long black hairs on each side in front; lower borders black; abdomen dark brown with the central region occupied by a wide, light gray, scalloped, longitudinal band; clypeus covered with long white hairs; falces dark reddish brown; sternum brown; palpus with a short brush of black hairs; legs dark brownish red, covered with adpressed white and upright black hairs. Venter pale gray, with a central longitudinal brown band which tapers to a point near the apex.

Habitat: United States, Mexico.

MARPTUSA CALIFORNICA Nov. Sp.

Plate I, figure 61. Plate V, figure 61. Plate VI, figure 61 a.

♂. Total length 9.2 mm. Width of abdomen 2.4 mm.

Cephalothorax: length 3.8; width 2.9; height 1.8.

Legs 8.4, 7.4, 7.5, 8; patella and tibia, 3.6; patella and tibia of the third, 3; patella and tibia of the fourth, 3.5; metatarsus and tarsus of the fourth, 2.5.

♀. Total length 9 mm. Width of abdomen 2.4 mm.

Cephalothorax: length 3.8; width 2.9; height 1.5; relative length of legs, 4, 1, $\overline{2\ 3}$.

Ocular area occupying a little more than one-third of cephalothorax, one-third wider than long, equally wide in front and behind. Anterior eyes in a slightly curved row; lateral one-half as large as middle eyes, separated from them by one-half their diameter; middle eyes subtouching; eyes of second row very slightly nearer lateral than dorsal eyes; dorsal not quite so large as lateral eyes, (♂) slightly nearer each other than lateral borders, (♀) further from each other, forming a line narrower than cephalothorax at that place. Clypeus vertical, one-half as high as middle eyes. Falces rather short and weak, vertical, parallel. Maxillæ parallel, enlarged and rounded at extremity. Labium more than one-half as long as maxillæ, as wide as long, rounded at tip. Sternum nearly plane, one-third longer than wide, widest in middle. Anterior coxæ separated by a little less than the width of labium. Femoral, patellary and tibial joints of the first

and second pairs, enlarged; femoral, tibial and metatarsal spines on the four pairs; those on the metatarsus of the fourth, throughout their length.

Coloration: Cephalothorax very dark brown covered with gray hairs, with whitish hairs around the eyes; central upper surface of abdomen occupied by a wide, angular gray band; sides black with mixed gray and tawny hairs; clypeus with white hairs; sternum, coxae and mouthparts brown; sternum with some white hairs; falces brown; venter black; legs, excepting the tarsi, which are light in color, blackish with much gray and tawny hair.

Habitat: California.

MENEMERUS MELANOGNATHUS H. LUCAS.

Plate I, figures 62, 62a. Plate VI, figures 62, 62a.

Syn.: 1839. (?). SALTICUS *melanognathus* H. Lucas, Webb and Berthelot's Hist. Nat. des Iles Canaries, Tom. II, p. 29, pl. VII, fig. 4.

1846. MARPISSA *dissimilis* C. L. Koch, Die Arachn., XIII, p. 70, Tab. CCCCLIV, figs. 1135 and 1136.

1846. " *incerta* id., ibid., p. 73, Tab. CCCCLIV, fig. 1138.

1859. SALTICUS *convergens* Doleschall, Tweede Bijdr. Arachn. Indischen Archipel, p. 15, Tab. IX, fig. 4.

1863. ATTUS *muscivorus* A. Vinson, Araneides des Iles de la Reunion, etc., p. 47, Pl. X, fig. 1.

1867. ATTUS *foliatus* L. Koch, Arach., etc., Verhandl. zool. and bot. Ges., in Wien, 1867, p. 226.

1870. SALTICUS *nigro-limbatus* Cambridge, Proceed. Zool. Soc. of London, 1869, p. 542, Pl. XLII, fig. 10.

1873. " *nigro-limbatus*, id., Transact. of the Linn. Soc. of London, XXVII, p. 527.

1874. MARPISSA *nigro-limbatus*, *id.*, Syst. list of Spiders of Gr. Britain and Ireland, ibid., XXX, p. 333.

1876. " *nigro-limbatus*, E. Simon, Arachnides de France, T. III, p. 29.

1878. ICIUS (?) *convergens* Thorell, Studi, etc., II, Ragni di Amboina, pp. 232, 309.

1879. MARPTUSA *marita* Karsch, West-Afrik. Arachn. in Zeitschr. f. die gesammt. Naturwissensch, LII, p. 338.

1879. MENEMERUS *foliatus* L. Koch, Arachn. Australiens, p. 1123, T. XCVIII, figg. 1, 2.

1881. ICIUS (?) *dissimilis* Thorell, Studi, etc., III, Ragni Malesi e. Papuani, p. 461.

1883. ATTUS *mannii* Peckham, New or little known spiders of the family Attidæ, p. 27, Pl. III, fig. 21.

1883. MENEMERUS *melanognathus* E. Simon, Arachn. de l'Ocean Atlantique, Soc. Entom., France, pp. 284, 306.

We have *Attus muscivorus* Vinson from both Madagascar and Reunion, and find it to be identical with *M. melanognathus.*

♂. Total length 8 mm. Width of abdomen 2.7 mm.

Cephalothorax: length 3.3; width 2; height 1.3.

Legs 7.8, 7.2, 5.9, 7.9; patella and tibia of the first, 3.6; patella and tibia of the third, 2.2; patella and tibia of the fourth, 3; metatarsus and tarsus of the fourth, 2.3.

♀. Total length 9.5 mm. Width of abdomen 3.6 mm.

Cephalothorax: length 3.8; width 3; height 1.5.

Legs 6.8, 6.5, 7.4, 8.5; patella and tibia of the first, 2.8; patella and tibia of the third, 2.5; patella and tibia of the fourth, 3.3; metatarsus and tarsus of the fourth, 3.

Cephalothorax low and flat, dilated behind dorsal eyes, with sides almost vertical in front and rounded widely behind; cephalic part scarcely inclined; thoracic part slanting very gradually until near the posterior border. Ocular area occupying less than two-fifths of cephalothorax, one-fourth wider than long, equally wide in front and behind. First row of eyes straight; middle eyes sub-touching; lateral rather more than one-half as large as middle eyes, and slightly separated from them; eyes of second row half way between lateral and dorsal eyes; dorsal as large as lateral eyes, further from each other than from lateral borders, forming a row narrower than the cephalothorax at that place. Clypeus scarcely one-fifth as high as middle eyes, vertical. Falces nearly as wide as the first row of eyes, more than twice as long as face, vertical, diverging a little at the extremities. Maxillæ parallel, long, narrow at base, rounded. Labium two-thirds as long as maxillæ, twice as long as wide, a little shorter in ♀ than in ♂, rounded at tip. Sternum deep set, nearly twice as long as wide, contracted in front, rounded behind. Anterior coxæ separated (♂) by about the width of the labium, (♀) a little less. Legs of the first pair a little stoutest. Femoral, tibial and metatarsal spines on the four pairs; metatarsi of the fourth spined throughout their length.

Coloration: Cephalothorax dark brown, with rufus hairs over anterior eyes, a wide white band low on each side, and a large patch of white hairs on the central thoracic region. Clypeus dark in the middle, with an oblique line of white hair on each side, these lines beginning below the anterior lateral eyes and extending over the clypeus and along the inner edges of the dark brown falces. Abdomen dark rufus with two wide longitudinal white bands composed of both short and long white hairs, and two black chevrons at the apex. Palpus with femur covered with white hairs, and tarsus black. Legs rufus with dark rings and a good many white hairs. Mouthparts, sternum and coxæ very dark, with white hairs. Venter gray with a wide central rufus band.

Habitat: Cosmopolitan. Florida, Mexico, Guatemala, Brazil, Islands of the Atlantic, England, France, Africa, Madagascar, Australia, Malay Archipelago.

MENEMERUS PAYKULLII AUD.

Plate I, 63. Plate VI, figures 63, 63a.

Syn.: 1825–27. ATTUS *paykullii* Aud. in Sav. Descr. de l' Egypte, 2. Edit., XXII, p. 172.
1837. " " Walck., Hist. Nat. des Insectes Aptères, I, p. 426.
1837. " *ligo* id., ibid., p. 426.
1845. " *binus* Hentz, Journal Bost. Soc. Nat. Hist., Vol. V.
1846. PLEXIPPUS *ligo* C. K., Die Arachn., XIII, p. 107.
1849. SALTICUS *vaillantii* Lucas, Expl. de l' Algerie Zool., I, p. 186.
1863. ATTUS *africanus* Vinson, Aran. des iles de 'la Réunion, Maurice et Madagascar, p. 52.
1865. EUOPHRYS *delibuta* L. Koch, Verhandl. d. zool. bot. Ges. in Wien, p. 874.
1875. ATTUS *binus* Hentz, Coll. Arachn. Writ. by N. M. Hentz, ed. by Burgess. Boston, p. 54.
1876. HASARIUS *paykullii* Sim., Arachnides de France, III, p. 81.
1881. MENEMERUS (?) " Thorell. Studi Sui Ragni Mal. et Pap., III, p. 501.
1881. " " Keyserling, Koch and Keyserling's, Die Arachn. Austral., p. 1461.
1885. " " Sim., Faune Archnologique de l' Asie Mérid., Bull. de la Soc. Zool. de France, p. 7.

We have *Attus africanus* Vinson from Madagascar and find it identical with *M. paykullii.*

♂. Total length 9 mm. Width of abdomen 2.7 mm.

Cephalothorax: length 4.5; width 3.1; height .2.

Legs 11, 9.2, 9.5, 10.5; patella and tibia of the first, 5; patella and tibia of the third, 3.5; patella and tibia of the fourth, 4; metatarsus and tarsus of the fourth, 4.

Cephalothorax high, convex, a little dilated behind dorsal eyes, with sides nearly vertical in front, and rounded behind; cephalic part inclined; thoracic part falling gradually from a little way behind dorsal eyes nearly to posterior border, then abruptly. Ocular area occupying two-fifths of cephalothorax, one-fourth wider than long, slightly wider in front than behind. Anterior eyes all projecting, in a curved row; middle eyes subtouching; lateral rather more than one-half as large as middle eyes, separated from them by one-third their own diameter; eyes of second row a little nearer lateral than dorsal eyes; dorsal smaller than lateral eyes, equally distant from each other and the lateral borders, forming a row narrower than the cephalothorax

at that place. Clypeus retreating, one-half as high as middle eyes. Falces not much wider than the two middle eyes, three times as long as face, vertical, parallel; fang not long. Maxillæ parallel, enlarged and rounded at extremity. Labium one-half as long as maxillæ, a little longer than wide, contracted and blunt at tip. Sternum nearly twice as long as wide, rounded behind, slightly contracted in front. Anterior coxæ separated by nearly the width of the labium. Legs of the first and second pairs stoutest; with femoral joints enlarged and compressed; femoral, patellary, tibial and metatarsal spines on the four pairs, those on third and fourth especially stout; metatarsi of the fourth spined throughout their length. There are some stout femoral spines on the palpus.

Coloration: Cephalothorax and abdomen white, with two wide longitudinal black bands extending from anterior eyes to spinnerets, and two white dots, one on each band, on the posterior part of the abdomen. Clypeus covered with white and rufus hairs; a reddish band extending from each anterior lateral eye downward to the lower border. Falces brown with fringes of white hairs on the inner borders. Mouthparts dark brown. Sternum and coxæ light brown. Venter black with a white band on each side. Palpi and legs light brown (legs of the first pair darkest) with white hairs and black spines.

Habitat: Florida, Guatemala, New Grenada (from collection of Count Keyserling), Europe, North Africa, India, Malay Archipelago, Australia, Madagascar.

HOMALATTUS (WHITE) 1841.

Cephalothorax rather low, as wide as long, flat above, a little contracted in front, the contraction beginning opposite the dorsal eyes, and truncated in front and behind, where it is hollowed to receive the anterior margin of the abdomen. Sides gently rounded. Cephalic part occupying about two-thirds of cephalothorax, not separated from thoracic part. Thoracic part level in the first half and then falling abruptly; this slanting portion being concealed by the overlapping abdomen gives the cephalic part, when looked at from above, an appearance of exaggerated length. Quadrangle of eyes much wider behind than in front, and, behind, one-third wider than long. First row of eyes straight or slightly curved; middle eyes near together; lateral one-half as large, and separated from the middle eyes, sometimes by more than one-half their own diameter. Eyes of second row at least twice as far from dorsal as from lateral eyes. Dorsal eyes as large as lateral, much further from each other than from lateral borders (often twice as far), forming a row as wide as cephalothorax at that place. Clypeus from one-fourth to one-half as high

as middle eyes. Maxillæ enlarged at extremity. Labium one-half as long, sometimes as wide as long, sometimes longer than wide. Sternum longer than wide, sometimes truncated in front, projecting between anterior coxæ. Anterior coxæ separated sometimes by more, sometimes by less, than width of labium.

The genus *Homalattus* is nearest *Ballus* from which it is not readily distinguished. The greater length of the cephalic part (two-thirds of cephalothorax instead of one-half as in Ballus) and the shape of the thoracic part enable one to decide. *Ballus* has the thoracic part contracted and the dorsum falling gently from the dorsal eyes; in *Homalattus* the sides are not contracted, and the fall, which does not begin at the dorsal eyes, is very abrupt. In *Zygoballus* the cephalothorax is very high and the thoracic part falls steeply from the dorsal eyes. *Rhanis* C. K., *Rhene* Thorell, and *Rhene* Tacz. are identical with *Homalattus* W.

HOMALATTUS CYANEUS HENTZ.

Plate I, figure 64. Plate VI, figures 64, 64a.

Syn.: 1845. ATTUS *cyaneus* Hentz, Journal Bost. Soc. Nat. Hist., Vol. V.
1848. MAEVIA *chrysea* C. Koch, Die Arachn., XIV, p. 83.
1875. ATTUS *cyaneus* Hentz, Coll. Arachn. Writ. by N. M. Hentz ed. by Burgess, Boston, p. 69.
1885. HOMALATTUS *septentrionalis* Keys., Neue Spinnen aus Amerika, VI, Verhandl. zool. bot. Gesel. in Wien, p. 29 (515).

♂. Total length 4.8 mm. Width of abdomen 1.2 mm.

Cephalothorax: length 1.8; width 1.5; height .7.

Legs 3.1, 2.2, 2, 2.5; patella and tibia of the first, 1.4; patella and tibia of the third, 8; patella and tibia of the fourth, 1; metatarsus and tarsus of the fourth, 1.

♀. Total length 4.6 mm. Width of abdomen 2.3 mm.

Cephalothorax: length 1.8; width 1.7.

Legs 3, 2.2, 2.4, 3.2; patella and tibia of the first, 1.2; patella and tibia of the third, 8; patella and tibia of the fourth, 1.1; metatarsus and tarsus of the fourth, 1.

Quadrangle of eyes barely one-third wider than long. First row of eyes straight. Anterior lateral separated from middle eyes by one-half their own diameter. Eyes of second row very small, and placed fully twice as far from dorsal as from lateral eyes. Clypeus one-half as high as middle eyes. Falces as wide as first row of eyes, one and one-half times as long as face, vertical, parallel, anterior surface plane. Maxillæ truncated. Labium one-half as long as maxillæ, about as wide as long, contracted and rounded at tip. Sternum oval, nearly

twice as long as wide. Anterior coxæ separated by about the width of the labium. First leg with femur, patella and tibia enlarged. Femoral, tibial and metatarsal spines on the four pairs.

Coloration. Our specimens are somewhat damaged: the ♂ has the scales all rubbed off and appears entirely black excepting some yellowish hairs on the clypeus, and pale rings on the metatarsi of the second, third and fourth legs. On the cephalothorax and abdomen of the ♀ there are left a few yellowish white, somewhat metallic scales; otherwise it is like the ♂. Hentz describes this species as brassy-green.

Count Keyserling has kindly sent us a specimen of his *H. septentrionalis* and we find it identical with *cyaneus*.

Habitat: Iowa, New York, Pennsylvania, Massachusetts, North Carolina, Alabama, Georgia, Nebraska.

BALLUS YOUNGII Nov. Sp.

Plate I, figure 66. Plate VI, figures 66, 66a, 66b.

♂. ♀. Total length 2.8 mm. Width of abdomen 1.4 mm.

Cephalothorax: length 1.5; width 1.2; height .6.

Legs 1.9, 1.7, 1.6, 2.1. Cephalothorax a little longer than patella and tibia of the first; patella and tibia of the third shorter than patella and tibia of the fourth; patella and tibia of the fourth longer than metatarsus and tarsus of the fourth.

Cephalothorax low, plane, a very little dilated behind middle, with sides vertical in front and slightly rounded behind; cephalic part not inclined; thoracic part not slanting until it reaches the posterior border, where it is truncated and a little hollowed. Ocular area occupying nearly one-half cephalothorax, one-third wider than long, slightly wider behind than in front. Anterior eyes touching, in a straight row; middle twice as large as lateral eyes; eyes of second row halfway between lateral and dorsal eyes; dorsal as large as lateral eyes, further from each other than from lateral borders, forming a row as wide as cephalothorax at that place. Clypeus much inclined backward, two-thirds as high as middle eyes. Falces very weak, about as long as face, parallel, inclined backward; fang very weak. Maxillæ parallel, short, wider and truncated at extremity. Labium short, twice as wide as long, rounded. Sternum oval, rather short. nterior coxæ separated by width of labium; coxæ of the fourth touching. Legs of the first and second pairs stoutest, with femoral joints compressed; inferior rows of spines on the tibiæ and metatarsi of the four pairs. Anterior end of abdomen fitting into excavation at pos terior end of cephalothorax.

Coloration: Cephalothorax, clypeus, abdomen and venter black, thinly covered with short yellow hairs; on the abdomen the thickening of these hairs forms two yellow spots on the anterior part, and three transverse yellow bands. Falces, mouthparts, sternum and coxæ light brown. Palpi and legs brown with some short yellow hairs.

The following remarks are from a letter written by Col. John J. Young, of Allegheny, Pa., to whom we are indebted for this species:

"These spiders are found at this season (November) under the bark of trees, usually hickory and sycamore. You will note that the general color of the spider corresponds with the rusty brown of the under side of the bark of the shag-bark hickory when first pulled off. In that hibernating locality it covers itself with a thin bluish envelope. The spider is so nearly of the bark color, and so small that we would often overlook the speck in the centre of the envelope, supposing it to be merely the empty tube or cell of some young spider."

Habitat: Pennsylvania.

NEON NELLII Nov. Sp.

Plate I, figure 65. Plate VI, figure 65.

♂. Total length 2.5 mm. Width of abdomen 1.2 mm.

Cephalothorax: length 1.3; width .9; height .5.

Legs —, 1.8, 2.1, 2.9.

♀. Juv. legs 4, 3, 1, 2.

Cephalothorax not high, convex, a little contracted behind dorsal eyes, sides nearly vertical in front, rounded behind; cephalic part much inclined; thoracic part sloping from just behind dorsal eyes. Ocular area occupying more than one-half cephalothorax, less than one-fifth wider than long, equally wide in front and behind. First row of eyes straight, all four touching; lateral one-half as large as middle eyes; eyes of second row a little nearer lateral than dorsal eyes; dorsal larger than lateral eyes, further from each other than from lateral borders, forming a row as wide as cephalothorax at that place. Clypeus slightly inclined, about one-fourth as high at middle eyes. Falces not as wide as two middle eyes, short, parallel, vertical; fang very weak. Maxillæ nearly parallel, rather long, rounded; labium wider than long, about one-third as long as maxillæ. Sternum convex, triangular, truncated in front. Anterior coxæ separated by more than width of labium. First legs stoutest; femoral, tibial and metatarsal spines on the four pairs; metatarsi of the fourth spined throughout their length.

Coloration: Cephalothorax brown, darkest in eye region. Abdomen brown with pale spots and chevrons. Palpi and legs pale with black rings; first legs darkest; remaining parts dark brown or black.

This species agrees with the genus *Neon* as defined by Simon, excepting that all the legs are spined.

Habitat: Pennsylvania, Canada (Collection of J. B. Tyrrell.)

ZYGOBALLUS SEX-PUNCTATUS HENTZ.

Plate I, figure 67. Plate VI, figures 67, 67a.

Syn.: 1844. ATTUS *sex-punctatus* H., Journal Bost. Soc. Nat. Hist., Vol. IV.
1875. " " id., Coll. Arachn. Writ. by N. M. Hentz. Ed. by Burgess, p. 54.

Total length 3 mm. Width of abdomen .8 mm.
Cephalothorax: length 1.8; width 1.6; height .8.
Legs 3.7, 2.2, 2, 3.

Cephalic part growing wider to the dorsal eyes; general appearance from above quadrangular, with projecting corners behind dorsal eyes; dorsal eyes placed on sides, below dorsum, forming a row wider by the amount of their projection than the cephalothorax at that place. Middle anterior eyes touching, lateral sub-touching; dorsal as large as lateral eyes. Labium two-fifths as long as maxillæ, as wide as long. Metatarsi of the third and fourth legs with only terminal circles of spines.

Coloration: Cephalothorax black with a spot of white hairs in front of each dorsal eye, and one between the dorsal eyes. Clypeus black, thinly covered with white hairs. Abdomen black with a white basal band and six white spots, two on each side near the middle of the dorsum, and two near the apex. Palpi and falces brown. Legs reddish or brown, first and fourth pairs darker than second and third. Under side black, with some white hairs on sternum and venter.

Habitat: North Carolina, Georgia, Florida.

ZYGOBALLUS BETTINI NOV. SP.

Plate I, figures 68, 68a. Plate VI, figures 68, 68a, 68b.

♂. Total length 4.2 mm. Width of abdomen 1.7 mm.
Cephalothorax: length 1.8; width 1.3; height 1,3.
Legs 4.9, 3.3, 3, 4.4.

♀. Total length 4.4 mm. Width of abdomen 2 mm.
Cephalothorax: length 1.8; width 1.4; height 1.1.
Legs 4.4, 3.2, 3, 4.5.

Clypeus inclined backward. Falces (♂) nearly as wide as first row of eyes, twice as long as face, inclined forward, diverging; fang long; (♀) extending only to inner edges of lateral eyes; one and one-half times as long as face, vertical, parallel; fang small. Maxillæ (♂) widest in middle, blunt at tip, cut obliquely on inner side; (♀) a little widest at extremity, rounded. Labium one-half as long as maxillæ, (♂) longer than wide, (♀) as wide as long. Legs without patellary spines, excepting one on the first leg, (♂) coxæ and trochanter of the first elongated.

Coloration: ♂. Cephalothorax bronze brown; eye region covered with reddish gold metallic scales; anterior faces of falces, clypeus and sides of cephalothorax as far back as second row of eyes, covered with white scale-like hairs. Abdomen bronze, with a silvery white band passing around base and downward onto the sides; a second white band, on each side, curves over the side from the upper to the under surface, and on the posterior dorsum are two more short curved white bands, these last being semi-circular in form. Mouth-parts, sternum and venter brown. First leg with elongated coxa and trochanter, as well as the femur, dark mahogany color; the other joints and all the other legs yellowish white.

♀. Cephalothorax bronze brown with metallic scales on eye region as in ♂. Anterior eyes surrounded by rings of reddish yellow hair. Abdomen brown; a white band passes around the base and extends on to the sides; beyond the termination of this are two short white bars on each side; on the anterior half of the dorsum is a wide longitudinal band composed of reddish golden scales; the posterior edge of this band is notched. Behind the band are two chevrons of the same scales, and two short bands, one on each side of the spinnerets; two black spots are found in front of the first, and two more behind the second chevron. Femur of the first leg mahogany color; other joints and all the other legs white with some dark rings and spots.

Habitat: Wisconsin, Missouri, Georgia, Florida

AGOBARDUS ANORMALIS KEYSERLING.

Plate I, figure 69. Plate VI, figure 74.

1885. AGOBARDUS *anormalis* Keys., Neue Spinnen aus Amerika, VI, Vernandl. zool. bot. Gesel. in Wien, p. 33 (519).

♂. Total length 4.7 mm. Width of abdomen 1.4 mm.

Cephalothorax: length 2.6; width 2.

Legs 6.7, 4.9, 5.5, 5.6; patella and tibia of the first, 2.3; patella and tibia of the third, 1.9; patella and tibia of the fourth, 1.9; metatarsus and tarsus of the fourth, 2.

♀. Total length 4.6 mm. Width of abdomen 1.7 mm.

Cephalothorax: length 2.1; width 1.6.

Legs 3.8, 3.3, 4.6, 4.8; patella and tibia of the first, 1.4; patella and tibia of the third, 1.6; patella and tibia of the fourth, 1.8; metatarsus and tarsus, 1.7.

Cephalothorax very high at dorsal eyes but, in front, not higher than clypeus and lateral eye, on account of the steep inclination of the cephalic part. Sides nearly parallel, a very little dilated in the middle, vertical in front, rounded behind; thoracic part falling steeply from dorsal eyes. Quadrangle of eyes occupying one-half of cephalothorax, twice as wide as long, equally wide in front and behind. First row of eyes much bent; middle eyes sub-touching; lateral a little more than one-half as large, separated from them by one-half their own diameter. Eyes of second row a very little nearer lateral than dorsal eyes. Dorsal as large as lateral eyes, equally distant from each other and the lateral borders, forming a row as wide as cephalothorax at that place. Clypeus one-fifth as high as middle eyes. Falces extending to inner edges of lateral eyes, one and one-half times as long as face, inclined backward, a little diverging; fang weak. Maxillæ slightly diverging, enlarged and rounded at extremity. Labium one-half as long as maxillæ, as wide as long. Sternum nearly as wide as long, oval, projecting between anterior coxæ. Anterior coxæ separated by nearly the width of the labium. Legs of the first pair a little stoutest. Femoral, patellary, tibial and metatarsal spines on the four pairs; those on metatarsi of the fourth extending to base.

Coloration: Cephalothorax brown with a lighter central longitudinal band in thoracic part, in the midst of which is a spot of white hairs; the eyes are placed in black spots; the anterior part of the cephalic plate, the lower sides, and the clypeus are covered with white hairs; the lower margin is black. Abdomen brown, with a curved white basal band and a central wide white longitudinal band which is often indistinct in the anterior part, and is interrupted behind by a slender brown transverse curved band; this middle band gives off on either side two short white spots which are longer than wide, one in the middle of the first half, the other, oblique, just in front of the spinnerets. Venter dark brown or black with a white band behind and on the sides. Palpi yellowish brown excepting the last two joints which are black, with black hairs. Falces, mouthparts, sternum coxæ and legs reddish brown.

Habitat: United States.

ATTUS CAUTUS Nov Sp.

♂ Juv. Total length 4.5 mm. Width of abdomen 1.6 mm.

Cephalothorax: length 2, width 1.5; height 9.

Legs 3, 3.2, 3.7, 4. Cephalothorax much longer than patella and tibia of the first; patella and tibia of the third shorter than patella and tibia of the fourth; patella and tibia of the fourth and metatarsus and tarsus of the fourth equal.

Cephalothorax moderately high, slightly convex, a little contracted behind, with sides vertical in front and rounded behind; cephalic part slightly inclined; thoracic falling gradually in the first two-fifths, then steeply. Ocular area occupying nearly one-half cephalothorax, one-third wider than long, equally wide in front and behind. Anterior eyes sub-touching, in a slightly curved row, the middle twice as large as the lateral eyes; eyes of second row halfway between lateral and dorsal eyes; dorsal as large as lateral eyes, a little further from each other than from lateral borders, forming a row as wide as cephalothorax at that place. Clypeus inclined backward, one-third as high as middle eyes. Falces as wide as the two middle eyes, as long as face, vertical, parallel. Maxillæ enlarged and blunt at extremity, parallel. Labium two-thirds as long as maxillæ, perhaps a little longer than wide, contracted and rounded at tip. Sternum one-fourth longer than wide, truncated in front. Anterior coxæ separated by more than width of labium. Legs of the first and second pairs slightly stoutest; femoral, tibial and metatarsal spines on the four pairs; metatarsi of the fourth spined throughout their length.

Coloration: Cephalothorax black with lower sides white, a white band above anterior eyes, another behind dorsal eyes, and a white spot in the middle of the cephalic part. Clypeus and falces covered with white hairs. Abdomen with the anterior third and the apex black, while the remaining portion is covered with bright yellowish brown hairs; there are four transvere white bands; two cross the anterior black region, one the brown region, and one separates the brown from the black region at the apex. Palpi light brown with thin white hairs. Mouthparts and coxæ light brown or pale. Sternum dark brown. Venter brown with a whitish longitudinal band on each side. Legs brown with blackish bands and some short white hairs.

Not wishing to found a new genus upon an immature specimen we put this species in the genus *Attus* Walck.

Habitat: Mexico.

SYNEMOSYNA (HENTZ) 1832.

Cephalothorax low, twice as long as wide, rounded and narrower behind; thoracic and cephalic part not separated; thoracic part plainly divided by two transverse constrictions and much longer than cephalic—sometimes twice as long. Quadrangle of eyes but little wider than long and a little wider behind than in front. First row of eyes a little curved; middle eyes touching, and three times as large as lateral eyes, from which they are slightly separated. Eyes of second row small and a little nearer lateral than dorsal eyes. Dorsal eyes larger than lateral and further from each other, than from lateral borders, forming a row as wide as cephalothorax at that place. Clypeus about one-fourth as high as middle eyes. Falces short, rather weak, vertical, parallel; fang weak. Maxillæ slightly enlarged and truncated at extremity, about twice as long as labium. Labium as wide as long, rounded. Sternum long, rather narrow, truncated in front, contracted behind, projecting between anterior coxæ. Anterior coxæ separated by at least the width of the labium at its base. Legs (♂) 4, 1, 3, 2, (♀) 4, 3, 1, 2, all slender; tibiæ and metatarsi of the first and the second, with two rows of inferior spines. Abdomen long, rounded, slender, with a marked constriction; pedicle of abdomen visible from above. *Synemosyna* differs from the other genera of ant-like Attidæ, in the following respects: *Synageles* Sim., *Leptorchestes* (Thorell) Sim., *Damœtas* Peckham, all have the quadrangle of the eyes longer than wide, and the constriction of the cephalothorax wanting, or, if present, very slight, and separating the cephalic and thoracic parts. *Agorius* Thorell has the patella of the first leg much elongated. *Paradamoetas* Peckham has no constriction of the cephalothorax. The last two genera resemble *Synemosyna* in having the quadrangle a little wider than long. It is nearest *Salticus* (Latr.) Sim.; *Salticus*, however, has the cephalic part on a higher plane than the thoracic, and the greater length of the maxillæ, and the labium being much longer than wide also distinguish it from *Synemosyna*.

SYNEMOSYNA FORMICA HENTZ.

Plate VI, figures 70, 70a.

Syn.: 1845. SYNEMOSYNA *formica* H., Journal Bost. Soc. Nat. Hist., Vol. V.
1846. JANUS *gibberosus* C. K., Die Arachniden, XIII, p. 21.
1875. SYNEMOSYNA *formica* H., Coll. Arachn. Writ. by N. M. Hentz. ed. by Burgess, Boston, p. 73.
1883. SYNEMOSYNA *formica* Peckham, Descr. new or little known Attidæ of U. S., p. 30.

♂. Total length 3.9 mm. Width of abdomen 7mm.

Cephalothorax: length 1.8; width .8; height .7.

Legs 3, 2.2, 2.5, 3.2; patella and tibia of the first, 1; patella and tibia of the third, .9; patella and tibia of the fourth, 1.3; metatarsus and tarsus of the fourth, 1.2.

♀ Total length 5.4 mm. Width of abdomen 1.8 mm.

Cephalothorax: length 2.2; width .7; height .8.

Legs 2.7, 2.2, 2.8, 3.5; patella and tibia of the first, 1; patella and tibia of the third, 1.1; patella and tibia of the fourth, 1.7; metatarsus and tarsus of the fourth, 1.5.

Cephalothorax with one constriction a little way behind the dorsal eyes, and another just in front of the juncture of the thoracic part with the abdominal pedicle; abdomen with a deep constriction before the middle, posterior to which it is enlarged and rounded.

Coloration: Cephalothorax brown, lighter on the upper surface, sometimes blackish on the sides, smooth, glabrous, with a few short white hairs in the eye region; abdomen in front of the constriction pale rufus, with a darker longitudinal band on the upper surface; behind the constriction b ack with a pale band, which is narrow in the ♂, but in the ♀ is wider, occupying the anterior sides and curving downward under the venter; clypeus blackish; falces black with pale edges; maxillæ and labium black, edged with white; sternum pale anteriorly, blackish behind; venter pale in front, black toward apex. Legs of the first pair pale with an internal and external black line on the femur, patella and tibia; second all pale; third pale, excepting femur, which is light rufus; fourth femur rufus, patella pale at proximal, blackish at distal end, tibia proximal end blackish, shading into pale toward metatarsus, metatarsus and tarsus pale.

Habitat: United States.

SYNAGELES PICATA HENTZ.

Plate VI, figure 71.

Syn.: 1845. SYNEMOSYNA *picata* H., Journal Bost. Soc. Nat. Hist. Vol. V.
1875. " " id., coll. Arachn. Writ by N. M. Hentz, ed. by Burgess, Boston, p. 75.

♀. Total length 4.2 mm. Width of abdomen 1.5 mm.

Cephalothorax: length 2; width .9; height .7.

Relative length of legs 4, 3, $\overline{1, 2}$.

Ocular area occupying a little more than one-half of cephalothorax, plainly longer than wide, and a little wider behind than in front. Anterior row of eyes very slightly curved; lateral less than one-half as large

as middle eyes, and slightly separated from them; eyes of second row twice as far from dorsal as from lateral eyes; dorsal eyes further from each other than from lateral borders. Clypeus fully one-half as high as middle eyes, vertical. Falces extending in width to inner edges of lateral eyes, a little longer than face, vertical, parallel. Maxillæ enlarged and blunt at extremity; labium semi-circular. Sternum twice as long as wide, contracted in front and behind. Anterior coxæ separated by scarcely the width of the labium. Abdomen with a constriction in front of the middle.

Coloration: Eye-region black with violet reflections; thoracic part reddish-brown with a short, transverse white band behind dorsal eyes. Anterior segment of abdomen reddish-brown; posterior segment glistening black with two white bands which begin at the constriction and curve downward over the sides. Venter with a semi-circular greenish-yellow spot behind the epigynum.

Habitat: North Carolina, Alabama, Wisconsin.

SYNAGELES SCORPIONA HENTZ.

Plate VI, figures 72, 72a.

Syn: 1845. SYNEMOSYNA *scorpiona* H., Journal Bost. Soc. Nat. Hist., Vol. V.

1875. " " id., Coll. Arachn. Writ. by N. M. Hentz, ed. by Burgess, Boston, p. 74.

♂. Total length 2.4 mm. Width of abdomen 5 mm.

Cephalothorax: length 1; width, 8; height, 4.

Legs 2, 1.5, 1.5, 2.6.

♀. Total length 3.5 mm. Width of abdomen 1.2 mm.

Cephalothorax: length, 1.4; width, 8; height, 5.

Patella and tibia of the first, 1; patella and tibia of the third, 8; patella and tibia of the fourth, 1.1; metatarsus and tarsus of the fourth, 8.

Ocular area occupying nearly two-thirds of the cephalothorax, a little more than one-third longer than wide, and wider behind than in front. Anterior row of eyes very slightly curved, lateral about one-half as large as middle eyes and separated from them by one-fourth their own diameter; eyes of second row not quite twice as far from dorsal as from lateral eyes; dorsal eyes further from each other than from lateral borders. Clypeus, (♂) less than one-half, (♀) one-half as high as middle eyes, vertical. Falces as wide as the two middle eyes, about as long as the face, vertical, parallel. Maxillæ rather long, a little enlarged at extremity, (♂) truncated, (♀) rounded; anterior coxæ separated by more than the width of labium. First legs a little the stoutest, dark.

Coloration: ♂. Cephalothorax brown; abdomen brown anteriorly, encircled by a white line in front of middle, behind which it is blackish; other parts brown excepting a pale spot on the anterior part of the venter. ♀. Cephalothorax brownish with the eyes on black spots; abdomen pale with two short, curved, dark bands near the spinnerets; falces brownish, venter pale with a dark region near the spinnerets; legs brown above, pale beneath; other parts all pale.

Habitat: New York, Ohio, North Carolina.

SALTICUS EPHIPPIATUS HENTZ.

Plate VI, figure 73.

Syn.: 1845. SYNEMOSYNA *ephippiata* H., Journal Boston Soc. Nat. Hist. Vol. V.

1846. SALTICUS *albocinctus* C. K., Die Arachinden, XIII, p. 36.

1875. SYNEMOSYNA *ephippiata* H., Coll, Arachn, Writ. by N. M. Hentz. Ed. by Burgess, Boston, p. 74.

♂. Total length 5.2 mm. Width of abdomen 1.4 mm.

Cephalothorax: length 2.4; width 1.4; height 1.2.

Legs 5.3, 4.1, 4.5, 6.1; patella and tibia of the first, 2.4; patella and tibia of the third, 1.8; patella and tibia of the fourth, 2.6; metatarsus and tarsus of the fourth, 2.

Cephalothorax moderately high and slightly convex; sides almost parallel; ocular area very slightly wider than long, and equally wide in front and behind; anterior eyes small, in a straight row; lateral about one-half as large as middle eyes, separated from them by one-fourth their own diameter; eyes of second row halfway between lateral and dorsal eyes; dorsal nearly as large as lateral eyes, and a little nearer each other than lateral borders. Clypeus less than one-fourth as high as middle eyes. Falces wider than first row of eyes, more than three times as long as face, inclined forward, diverging; fang as long as falx. Maxillæ long, slender, blunt at tip, about twice as long as wide, parallel. Labium less than one-half as long as maxillæ, about as wide as long, blunt. Sternum narrow, and more than twice as long as wide. Anterior coxæ separated by width of labium. Legs all slender and long; tibial and metatarsal spines on the four pairs; the metatarsi of the fourth spined throughout their length. Abdomen with a constriction in front of middle.

♀ Total length 5 mm. Width of abdomen 1.2 mm.

Cephalothorax: length 2.2; width 1.2; height 1.

Legs 3.8, 3.1, 3.4, 5.3; patella and tibia of the first, 1.8; patella and tibia of the third, 1.3; patella and tibia of the fourth, 2; metatarsus and tarsus of the fourth, 2.

Clypeus one-fourth as high as middle eyes. Falces extending in width only to the inner edges of the lateral eyes, as long as the face, parallel, and slightly inclined forward; fang short. Maxillæ less than twice as long as wide. Labium more than one-half as long as maxillæ.

Coloration: Cephalothorax brownish; abdomen brown in front of constriction, black behind, encircled by a white line at the constriction; falces dark with white hairs; clypeus, mouthparts, sternum, coxæ and venter brown; legs with a tinge of yellow.

Habitat: Pennsylvania, New York, Alabama.

LYSSOMANES HENTZ.

Syn.: 1844. LYSSOMANES Hentz, Journal Boston Soc. Nat. Hist., Vol. IV.

Cepalothorax moderately high, sloping downward behind and on the sides from the caput, about one-third longer than wide. General form oval. Caput occupying one-half or nearly one-half of cephalothorax.

Eyes arranged in four transverse rows of two each. Eyes of first row close together, from two to three times as as large those of second row, occupying the entire face. Second row just behind first and about as wide (sometimes a little wider or narrower). Third row composed of two very small eyes, plainly nearer the second than the fourth row, narrower than the second and wider than the fourth. Eyes of fourth row about as large as those of second and nearer together; quadrangle formed by second and fourth rows as wide as long, or from one-fourth to one-third wider.

Sternum somewhat heartshaped; length and width about equal. Coxæ separated by the width of the labium and part or all of the maxillæ. Maxillæ slightly enlarged at extremities. Labium about as wide as long or a little longer than wide. Abdomen long, slender, tapering; spinnerets short. Legs usually long and slender; relative length variable. Long and slender femoral, tibial, metatarsal and usually patellary spines on the four pairs.

LYSSOMANES VIRIDIS HENTZ.

Syn.: 1844. LYSSOMANES *viridis* Hentz, Jour. Boston Soc. Nat. Hist., Vol. IV.

1875. " " id., Coll. Arachn. Writings. Ed. by Burgess, Boston, p. 49.

♂. Total length 6.5 mm. Width of abdomen 1.5 mm.

Cephalothorax: length 2; width 2; height 1.3.

Legs 12, 9.5, 8.5, 8; patella and tibia of the first, 4.5; patella and tibia of the third, 3; patella and tibia of the fourth, 3; metatarsus and tarsus of the fourth, 3.2. Falx 2.5.

♀. Total length 8 mm. Width of abdomen 2.4 mm.

Cephalothorax: length 3; width 2.6; height 1.8.

Legs 10.5, 9, 8.3, 8; patella and tibia of the first, 4.5; patella and tibia of the third, 3; patella and tibia of the fourth, 3; metatarsus and tarsus of the fourth, 3.4.

Coloration: Cephalothorax and abdomen light yellow; cephalothorax with a slender, central, dark, longitudinal line on the thoracic part; eyes of second and third rows on black tubercules. Abdomen with six black dots (sometimes wanting) arranged in two longitudinal rows. There are some orange colored hairs around the anterior eyes, and in the male the falces are reddish in front. The other parts are light yellow.

Hentz describes this species as being tender grass-green. The color probably changes in alcohol.

Habitat: Southern United States.

DESCRIPTION OF PLATES.

PLATE I.

1. Phidippus morsitans, ♀; 1a, epigynum.
2a. " rufus, epigynum.
3. " galathea, ♀; 3a, epigynum.
5. " obscurus ♀.
6. " minatus, ♀; 6a, epigynum.
8. " ranterbergii, ♀.
10. " arizonensis, ♂.
12. " insolens, ♀.
13. " albomaculatus, ♀.
14. " johnsonii, ♀.
15. " otiosus, ♀.
16. Philæus farneus, ♀.
17. " fartilis, ♀.
18. " mexicanus, ♀.
19. " militaris, ♀.
19a. " " ♂.
20. " chrysis, ♀.
22. " rimator, ♀.
23. Plexippus puerperus, ♂. (Figure blurred on plate.)
23a. " " ♀.

25. Dendryphantes capitatus, ♂.
25a, 25b. " " ♀, two varieties.
27. " flavus, ♀.
30. Attus palustris, ♀.
32. Icius lineatus, ♀.
33. Icius palmarum, ♀.
34. " mitratus, ♀.
35. " piraticus, ♂.
35a. " albovittatus, ♂.
36. Pseudicius harfordii, ♀.
36a. " " ♂.
37. Eris octavus, ♀.
39. " nervosus, ♀.
40. Hasarius hoyi, ♀.
40a. " " ♂.
42. Habrocestum cœcatum, ♀.
43. " viridipes, ♀.
44. " peregrinum, ♂.
45. " cristatum, ♀.
46a. " auratum, ♀.
48. " splendens, ♀.
50. Saitis pulex, ♀.
50a. " " ♂.
51. Prostheclina cambridgii, ♀.
52. Astia vittata, ♀.
52a. " " ♂.
53. Astia morosa, ♀.
55. Cytæa minuta, ♀.
56. Cyrba tæniola, ♀.
57. Epiblemum scenicum, ♀.
58. Admestina wheelerii, ♂.
59. Hyctia pikei, ♂
60. Marptusa familiaris, ♀.
61. " californica, ♀.
62. Menemerus melonagnathus, ♂.
62a. " " ♀.
63. " paykulli, ♀.
64. Homalattus cyaneus, ♂.
65. Neon neelii, ♂.
66. Ballus youngii, ♀.
67. Zygoballus sexpunctatus, ♂.
68. " bettini, ♀.
68a. " " ♂.
69. Agobardus anormalis, ♀.
70. Sadala distincta, ♂.

PLATE II.

1. Phidippus morsitans, ♂ palpus.
2. " rufus, ♂ palpus.
4. " cardinalis, ♂ palpus
5 " obscurus epigynum.
7. " mexicanus, ♂ palpus.
8. " rauterbergii, epigynum.
9. " mc 'cookii, epigynum.
10. " arizonensis, ♂ palpus.
11. " opifex, epigynum.
12. " insolens, palpus of ♂; 12a epigynum.
13. " albomaculatus, epigynum.
14. " johnsonii, palpus of ♂; 14a epigynum.
15. " octopunctatus, ♂ palpus.
15a. " otiosus, epigynum.
16. Philæus farneus, epigynum.
17. Philæus fartilis, epigynum.
18. " mexicanus, epigynum.
19. " militaris, palpus of ♂; 19a epigynum.
20. " chrysis, ♂ palpus.
23. Plexippus puerperus, ♂ palpus; 23a, tibia of ♂ palpus. For epigynum see Plate III, fig. 23b.

PLATE III.

20a. Philæus chrysis, epigynum; —aurecalceus = chrysis.
21. " princeps, epigynum.
23b. Plexippus puerperus, epigynum.
24. " putnamii, ♂ palpus.
25. Dendryphantes capitatus, palpus of ♂; 25a, epigynum.
26. " elegans, palpus of ♂; 26a, epigynum; 26b, first leg of ♂. For mouthparts and falces of ♀ see Plate IV, fig. 26c.
27. Dendryphantes flavus, epigynum; 27a, mouthparts and falces of ♀.
28. Dendryphantes multicolor, epigynum; 28a mouthparts and falces of ♀.
29. Dendryphantes alboimmaculatus, epigynum.
29a. " flavipedes, ♂ palpus.
30. Attus palustris, palpus of ♂; 30a, epigynum.
31. " imperialis, ♂ palpus; 31a, mouthparts and falces of ♂.
32. Icius lineatus, ♂ palpus; 32a, same, from one side; 32b, epigynum.

33. Icius palmarum, palpus of ♂; 33a, epigynum.
34a. " mitratus epigynum. For ♂ palpus see Plate IV, fig. 34.
36. Pseudicius harfordii, epigynum. For ♂ palpus see Plate IV, figure 36a.
37. Eris octavus, epigynum.
39. " nervosus, epigynum.

PLATE IV.

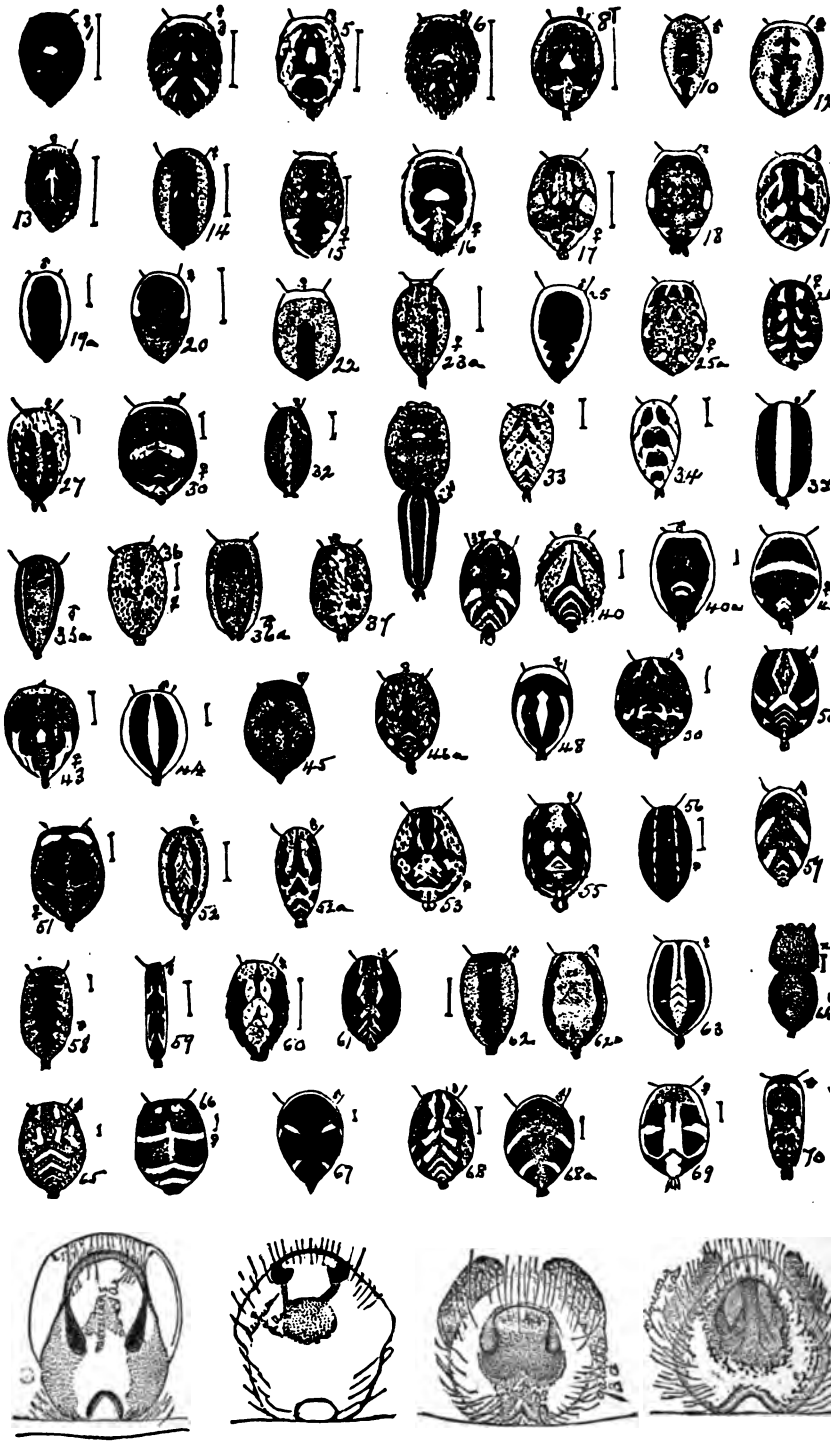
26c. Dendryphantes elegans, falces and mouthparts of ♀.
34. Icius mitratus, ♂ palpus.
35. " piraticus, ♂ palpus; 35a, same from outer side.
35d. " albovittatus ♂ palpus.
36a. Pseudicius harfordii, ♂ palpus.
38. Eris barbipes, epigynum; 38a, first leg of ♀.
40. Hasarius hoyi ♂ palpus; 40a, epigynum.
42. Habrocestum cœcatum, palpus of ♂; 42a, epigynum; 42b, third leg of ♂ from behind.
43. Habrocestum viridipes, ♂ palpus; 43a, epigynum.
44. " peregrinum ♂ palpus; 44a, patella of third leg of variety 1; 44b, same of variety 2.
45. " cristatum, epigynum.
46. " auratum, epigynum; 46a, ♂ palpus; 46b, mouthparts and falces of ♂.
47. " hirsutum, first leg of ♂; 47a, ♂ palpus.

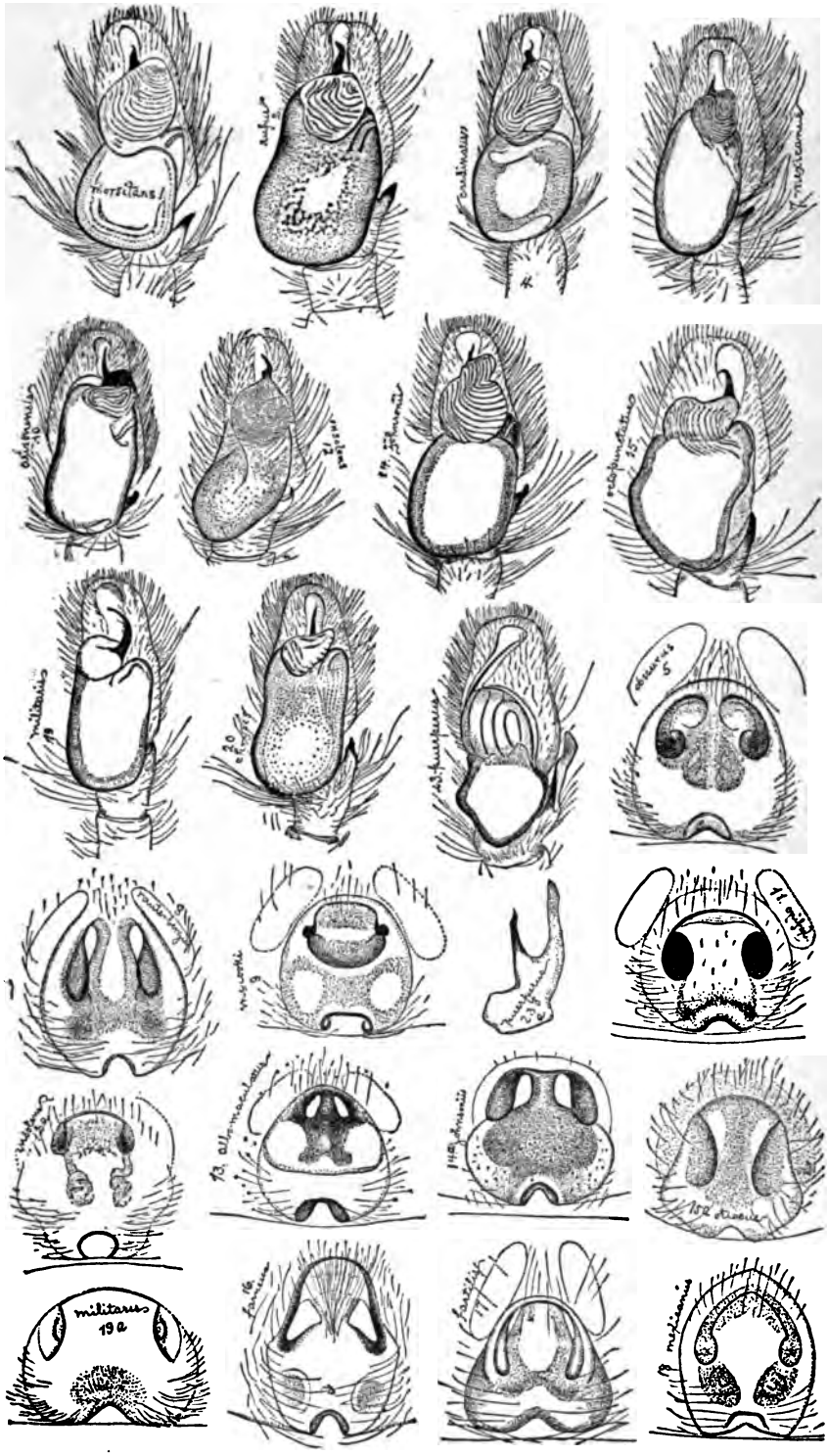
PLATE V.

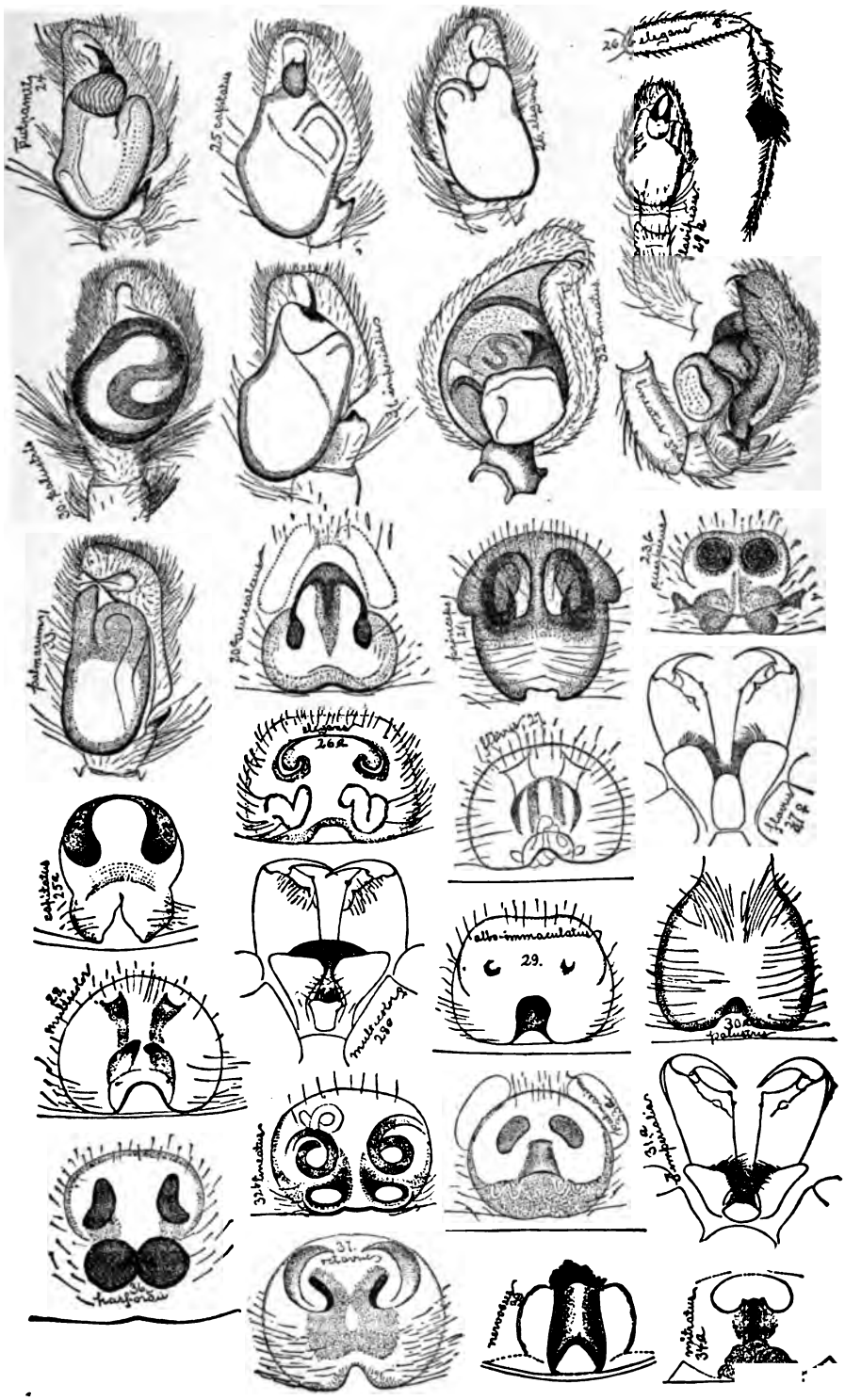
48. Habrocestum splendens, ♂ palpus; 48a, epigynum.
49. " oregonense, ♂ palpus; 49a, first leg of ♂.
50. Saitis pulex, epigynum; 50a, ♂ palpus.
51. Prostheclina cambridgii, ♂ palpus; 51a, epigynum.
52. Astia vittata, ♂ palpus; 52a, epigynum.
53. " morosa, ♂ palpus; 53a, epigynum.
54. Maevia californica, ♂ palpus; 54a, mouthparts and falces.
55. Cytæa minuta, ♂ palpus; 55a, epigynum.
56. Cyrba tæniola, ♂ palpus; 56b, mouthparts and falces of ♀. For epigynum see Plate VI, fig. 56a.
58 Admestina wheelerii, ♂ palpus.
59. Hyctia pikei, ♂ palpus. For epigynum see Plate VI, fig. 59a.
60. Marptusa familiaris, ♂ palpus. For epigynum, see Plate VI, fig. 60a.
61. " californica, ♂ palpus. For epigynum, see Plate VI, fig. 61a.

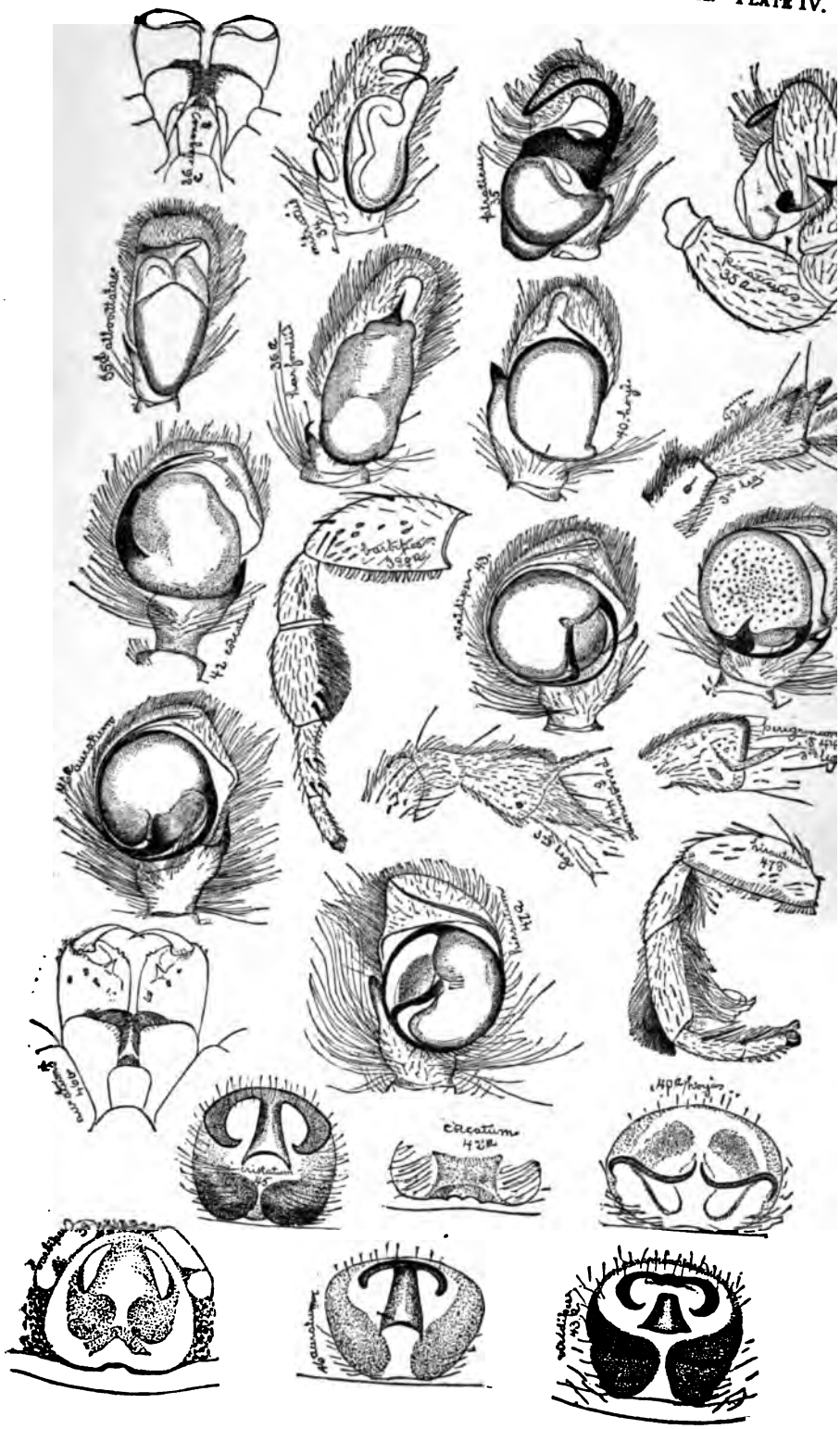
PLATE VI.

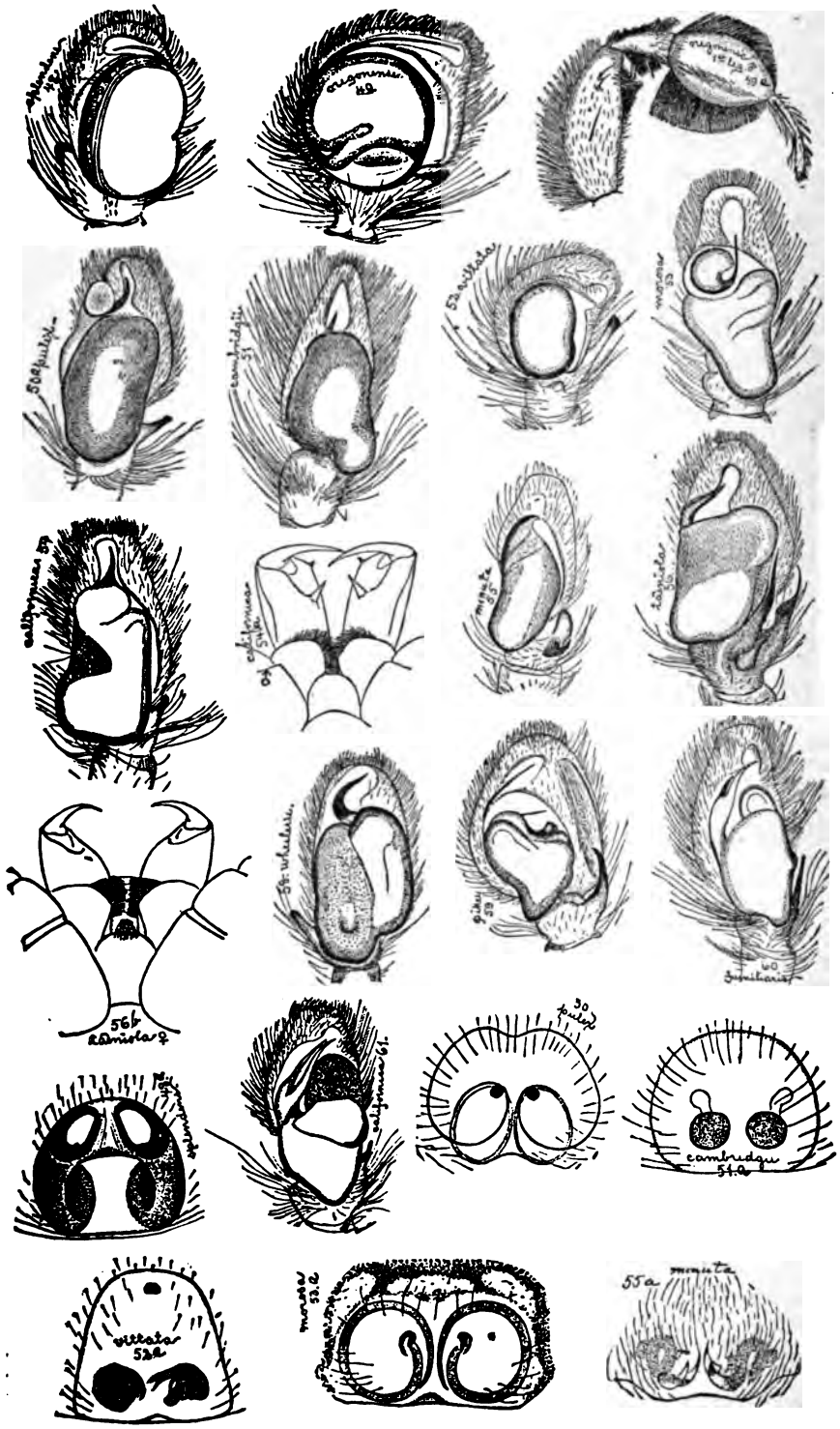
56a. Cyrba tæniola, epigynum.
57. Epiblemum scenicum, epigynum.
59a. Hyctia pikei, epigynum.
60a. Marptusa familiaris, epigynum.
61a. " californica, epigynum.
62. Menemerus melanognathus, ♂ palpus; 62a, epigynum.
63. " paykullii, ♂ palpus; 63a, epigynum.
64. Homalattus cyanens, ♂ palpus; 64a, epigynum.
65. Neon nellii, ♂ palpus.
66. Ballus youngii, ♂ palpus; 66a, same from one side; 66b, epigynum.
67. Zygoballus sexpunctatus, mouthparts and falces of ♂; 67a, ♂ palpus.
68. " bettini, ♂ palpus; 68a, epigynum; 68b, falces and mouthparts of ♂.
70. Synemosyna formica, ♂ palpus; 70a, epigynum.
71. Synageles picata, epigynum.
72. " scorpiona, epigynum; 72a, ♂ palpus.
73. Salticus ephippiatus, ♂ palpus.
74. Agobardus anormalis, ♂ palpus.
76. Sadala distincta, ♂ palpus.

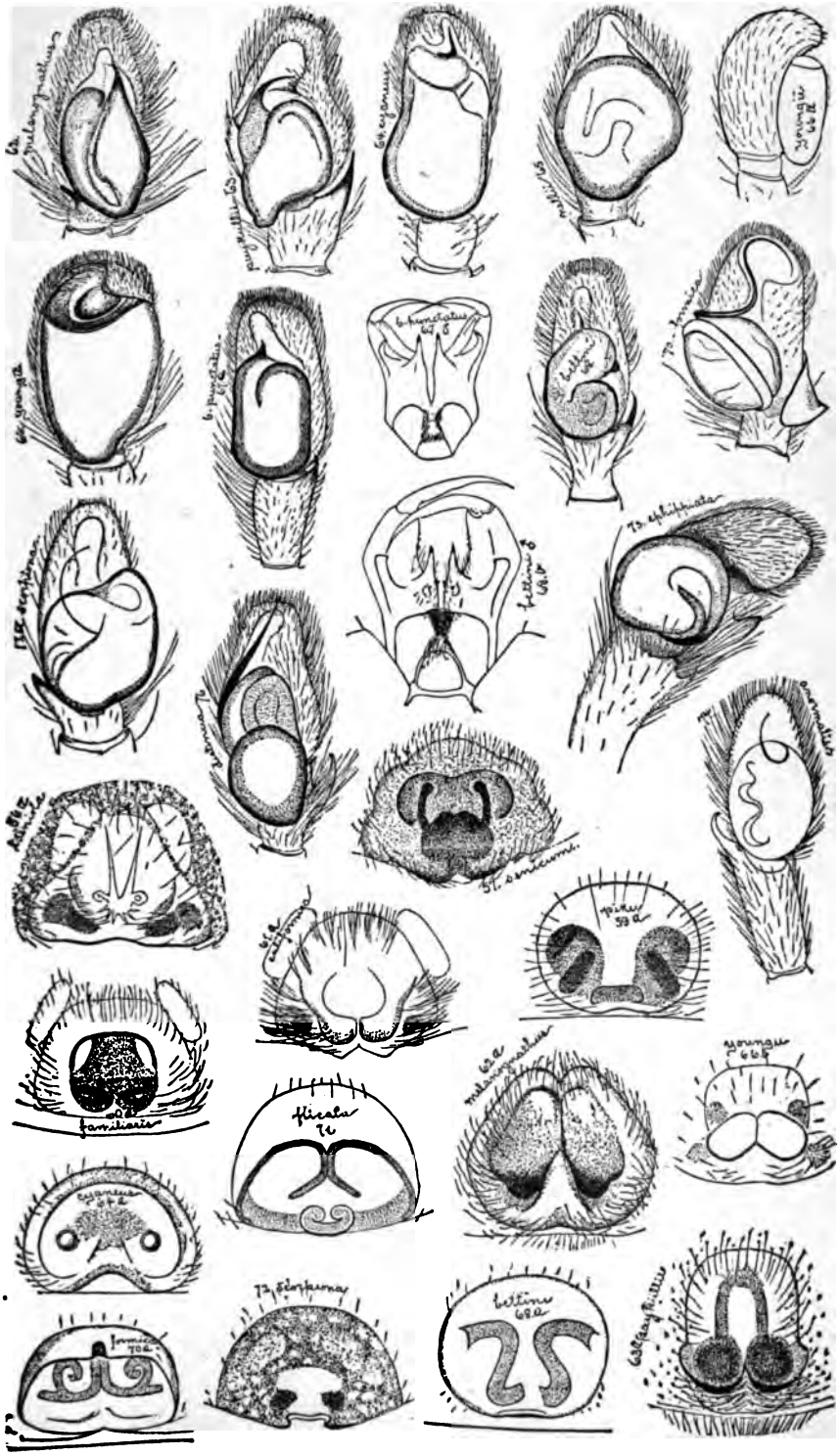



militaris
19a


26. elegans
25 californicus
26 R.
alba-immaculatus
29.
30 polyporus
31 R. Emarginatus
31. ritanus
32 R.
31 R. Pumilus
31 R.







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THE MORELS AND PUFF-BALLS OF MADISON.

By WILLIAM TRELEASE.

To facilitate the work of collectors engaged with the cryptogamic botany of the state, a preliminary list of the parasitic fungi of Wisconsin was presented to the Academy at its meeting in the winter of 1882.[1] In continuation of that list, the following descriptions of non-parasitic species are offered for publication. The groups that have been selected are not closely related, as might have been inferred from their treatment in a single paper, nor do they include many species: but they possess some general interest because the majority of the species are edible, and they derive scientific interest from the fact that their discrimination is attended with considerable difficulty.

Several correspondents have favored me with their collections for study, and I am under especial obligation in this respect to Dr. J. J. Brown of Sheboygan. The names that have been adopted rest upon a comparison of our specimens with the rich collections of Professors C. H. Peck, of the New York State Museum, and W. G. Farlow, of Harvard University, the latter of which includes the Curtis herbarium, and hence contains types of the species of Berkeley and Curtis, described in Grevillea. My thanks are also due these gentlemen for the use of papers not otherwise accessible to me, and for opinions on doubtful forms. Similar opinions have also been given by the late Dr. G. Winter, of Comrewitz, Germany, Professor P. Magnus, of Berlin, and Dr. M. C. Cooke, and Mr. George Massee, of London; but for the nomenclature adopted I am personally responsible. While it is believed that the names employed are in accordance with the opinion of the best authorities on American fungi, it is by no means certain that references to the older European names are in all instances above suspicion, for many descriptions and figures are insufficient, and the paucity of authentic specimens, as well as the poor state of preservation of some of those extant, contribute to the general uncertainty.

I. MORELS.

Order ASCOMYCETES. Sub-Order DISCOMYCETES.

The popular name of Morel corresponds to the genus *Morchella*, which comprises fleshy fungi with a rather stout hollow stem, bearing at the top a dilated round or conical head, reticulated by prominent ridges that sepa-

[1] Transactions, vi, 106. Reprints of the paper were issued early in November 1884, in advance of the volume.

rate coarse depressions. This head, or pileus, is covered externally by elongated sterile bodies (paraphyses) and oblong spore-sacs (asci), both microscopic. In our species the asci contain eight ellipsoidal spores each; but others are known in which only two spores are found in each ascus.—The two species that have been collected about Madison are distinguished by the character of the pileus.

Pileus aduate to the stipe, coarsely pitted..... *M. esculenta.*
Pileus free, at least for its lower half, longitudinally ribbed..... *M. hybrida.*

1. MORCHELLA ESCULENTA (Mich.)—Stipe stout, somewhat mealy or furfuraceous. Pileus variable, round to conical, regularly and coarsely pitted. Spores 10—13.5×17—23μ.—Mostly in white oak woods, in the spring. Reported in Bundy's list of Wisconsin fungi.[1]

In the commonest form the plant is two to four inches high, with the stipe and pileus of nearly equal length; the latter oblong, obtuse, and not much dilated. Another type, which is not uncommon, is rather shorter, with the pileus considerably dilated and nearly spherical. In a less frequent form it is elongated and decidedly conical. All are found in open dry woods, and are most abundant under or near white oak trees (*Quercus alba*).[2]

Occasionally they are found in meadows, and I once collected a number of unusually large specimens on the side of a high, gravelly railroad embankment, in company with *Equisetum arvense*, entirely removed from trees of any kind. Young specimens, with an elongated smoky pileus, the tops of the ridges only being pale, agree with var. *cylindrica* as figured by Vittadini[3] who recognized it as an immature state.

Figures:—Cooke, Mycographia, i, pl. 81, f. 312. *Exsiccatae:*—Ravenel, Fungi Carol, i. no. 36; Ellis, N. A. Fungi, no. 979.

Other similar species referred to by writers on American fungi are *M. crassipes* Fr. (Bull. Washburn Laboratory, i, 70), *M. elata* Fr. (Grevillea, iii, 149; Bull. Buffalo Soc., ii, 286), *M. deliciosa* Fr. (30 Rep. N. Y. Museum, 58), and *M. conica* P. (Mycographia, i. pl. 81, f. 315; Cat. Pac. Coast fungi, 33; Bull. Washburn Lab. i. 70.—*M. esculenta*, var. *conica* of Bull. Buffalo Soc. ii, 286 and Curtis, Catalogue, 131). The first two are large, the first, especially, with a much inflated stipe; the others are smaller and more delicate. Perhaps one or more of them occur among the Madison specimens, but I am unable to separate our plants by any constant or good characters.

2. MORCHELLA HYBRIDA (Sow.) P.—Stipe usually slender (one-fourth to one-half inch), furfuraceous or smoothish, with more or less red-brown transverse striation. Pileus short (three-fourths inch or less), conical or thimble

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[1] Report. Geol. Surv. Wis., Vol. 1, p. 401.

[2] Harkners and Moore speak of *M. esculenta* as growing under oaks (Cat. Pacific Coast Fungi, 33). James finds it usually under the ash (Ohio Agric. Rep., 1881, 97). According to Peck, the commonest form about Albany is found under or in the vicinity of pines (28 Rep. N. Y. Museum, 86), and Day also finds it under conifers (Cat. Buffalo Plants, 152).

[3] Descrizione dei funghi mangerecci più communi dell' Italia, 105, note, pl. 13, f. 4–5.

shaped, its lower half free from the stipe, longitudinally ribbed but with few transverse ridges. Spores about 17×27 μ.—Damp shady woods, in spring; less common than the first.

Two species of De Candolle are included under this name: the first, *M. semilibera*, with a smooth stem; the second, *M. rimosipes*, furfuraceous. If they are distinct, our plant belongs to the latter, though the first has usually been recognized as the American plant. Vittadini[1] could not separate these forms, nor am I able to do so. The character of the stipe is too inconstant to be of value, at least in herbarium specimens, for watery plants, grown in wet weather, often have their translucent stems apparently nearly or quite smooth when pressed. Both forms are represented in English specimens distributed by Broome[2] as *M. semilibera*. *M. patula* P., if distinct, seems to be characterized chiefly by the greater prominence of transverse ridges, making the depressions of the pileus more regularly polygonal. *M. bispora* Sow., with a free pendent pileus, which is found in New York,[3] may be distinguished, if it also occurs in Wisconsin, by having 2-spored asci.

M. esculenta is esteemed for the table by most persons, and has usually been held to be entirely free from the noxious properties resident in many fungi. Under some conditions, however, the plants may develop poisonous principles; and when eaten raw, or even if the water has not been changed while cooking them, they occasionally give rise to indigestion or symptoms of poisoning. This is especially true of specimens gathered in wet weather, and of those which are past their prime or have been kept too long before cooking, for like all fleshy fungi they are readily putrescible. But where proper care is taken in selecting and cooking the specimens, the morel forms an excellent relish and is one of the safest of edible fungi. What has been said of this species applies generally to the genus *Morchella*, but I have eaten none of the other species.[4]

The only fungi that are likely to be confounded with morels are certain related genera, *Helvella*[5] and *Gyromitra*,—which produce asco-spores on the exterior of the folded but not reticulately ribbed or pitted pileus;—and the stink-horn fungi,—species of the basidiomycetous genus *Phallus*.[6] Most of the former are edible. No person possessing the sense of smell is likely

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[1] *l. c.* 114.

[2] Rabenhorst's Fungi Europaei, No. 1417.

[3] Peck; 30 Rep. N. Y. Museum, 58.

[4] For an abstract of recent papers on the necessity for caution in preparing morels, see Bot. Centralblatt, xx. 243, and a paper by Böhm and Külz, in Archiv. für experiment. Pathologie und Pharmakologie, xix. Heft. 6 (Abst. in Bot. Zeitung, 1886, 643-4).—Useful recipes for the preparation of these fungi will be found in Röll: Die 24 häufigsten essbaren Pilze. Tübingen, 41-5.

[5] *Helvella crispa* (sometimes said to be poisonous) occurs in open woods about Madison, in late summer and fall.

[6] *P. duplicatus* Bosc, is common about Madison in summer and autumn, in lawns, grass by the roadside, etc.; and *P. caninus* has been collected at La Crosse by Mr. L. H. Pammel.

to entertain the thought for a moment of collecting the latter except under protest, and never of eating them, at least when mature.

II. PUFF-BALLS.

Order BASIDIOMYCETES. Sub-Order GASTEROMYCETES.

Fungi belonging to the Family *Lycoperdaceae* are usually, spoken of as puff-balls, from the powdery character of their spores, that in most species are emitted in clouds on the slightest touch. When young the plants are rounded, colorless and fleshy, and most of the species are then edible. Immature phalloids, already referred to, may be mistaken for puff-balls, but when cut across they show a layer of translucent jelly just under the surface. When ripe, the pretty little *Lycogala epidendrum*, which is comm on about Madison ondecaying wood, and the subterranean *Elaphomyces granulatus*, that we have not yet found, resemble, respectively, *Lycoperdon* and *Scleroderma* in their general appearance, but differ greatly in their development and fructification, the former belonging to the Myxomycetes, the latter to the Ascomycetes.

Our species of puff-balls may be referred to their genera by the appended key, which, it should be observed, refers only to Madison species and makes no provision for those which occur elsewhere:

Outer peridium forming a star when mature..... *Geaster.*
Outer peridium not star-shaped.
  Spores mixed with a conspicuous thread-like capillitium.[1]
    Entire plant filled with spores and threads, the latter dichotomous from a main trunk..... *Bovista.*
    Base usually more or less spongy and sterile: threads without a main stem..... *Lycoperdon.*
  Spores when ripe without a fleecy capillitium.
    Plant with a solid central columella: spores brownish..... *Secotium.*
    Without a columella; spores purplish..... *Scleroderma.*

SYNOPSIS OF GEASTER.

Inner peridium sessile.
  Mouth few-toothed, not prominent, nor on a disk..... *G. hygrometricus.*
  Mouth silky-striate, conical, on a round disk..... *G. saccatus.*
Inner peridium stalked.
  Mouth protruding, deeply plicate, plant small ..... *G. Rabenhorstii.*
  Mouth not prominent or plicate, plant rather large..... *G. limbatus.*

1. GEASTER HYGROMETRICUS. P.—Outer peridium leathery, usually irregularly 8-to-10-rayed, the lobes often notched or forked at apex; with a thick waxy inner layer cracking when dry, opening and closing with changes in moisture when fresh. Inner peridium sessile, depressed, rough-scurfy, with a star-shaped or irregularly torn, scarcely protruding mouth. Capillitium somewhat anastomosing. Spores rough, 10 to 12 μ. in diameter.—Pl. 1, f. 1.—Sandy places, in summer and autumn.

[1] For a comparative study of the capillitium of these and other genera see Hesse: Jahrb. f. wiss. Bot. x. (4), 383, pl. 28-29; Abst. in Bot. Jahresbericht, iv. 163.

A poor specimen was once picked up on the shore of Fourth Lake. The species is also reported from Wisconsin by Bundy, and has been collected at La Crosse (*Pammel*), River Falls (*King*), and Sparta (*Miss Rose Schuster*): it ranges over the entire country, from the Atlantic to the Pacific, and is abundant in Europe.

Figures:—Morgan, American Naturalist, xviii, 969, f. 12; Trelease, St. Nicholas, xiii, 875, f. 2. *Exsiccatae:*—Ravenel, Fungi Carol., iii, No. 75; Fungi Amer. No. 471; Von Thuemen, Mycotheca Universalis, No. 110; Ellis, N. A. Fungi, No. 108.

2. GEASTER SACCATUS Fr.—Outer peridium usually eight to ten lobed, the sinuses extending halfway to the base, the lobes reflexed; varying from cream-color to dark brown, the darker specimens occasionally white-striped on the outside from the cracking of the outermost layer. Inner peridium usually a little paler, sub-globose. Mouth prominent, conical, on a distinctly marked disk, silkystriate, sometimes darker than the rest of the peridium. Spores brown, semi-opaque, coarsely warted, 3.7 to 5 μ. Pl. 1, f. 2. Abundant in damp woods. August and September.

This species, extremely variable in size and color, has been variously referred by writers. The type (represented in the Lapham herbarium, from the Penokee Iron Range) is larger and coarser than our form, which corresponds nearly to *G. vittatus*, Kalchbr., but the white striping of the outer peridium is exceptional, for specimens growing together differ in this respect, though evidently belonging to a single species. In size and general appearance our plant resembles *G. fimbriatus* Fr., the mouth of which, as indicated in descriptions and shown by European exsiccatae, is less prominent and not on a sharply limited disk.

Figures:—Morgan, *l. c.* 968, f. 9. *Exsiccatae:*—Ravenel, Fungi Carol., i, no. 77.

3. GEASTER RABENHORSTII Kunze.—Small. Outer peridium at length papery, whitish buff, mottled with dark brown; divided into six to eight strongly reflexed lobes. Inner peridium lead-color or brown, distinctly stalked with a prominent apophysis at summit of stipe. Mouth conical or cylindrical, deeply furrowed longitudinally. Spores dark brown and opaque, irregularly globose, coarsely papillate, 4.5 to 5 μ.—Pl. 1, f. 3.—Sandy woods.

Found once in small numbers under a clump of larches on the University grounds. I have seen the same plant in the collection of Professor Peck, at Albany. It has doubtless often passed for a small form of *G. striatus* (DC.), and is referred to that species by Peck (38 Rep. N. Y. Museum, 94). It is *G. Schmideli* Vitt. of Winter's Kryptogamen Flora, and may really be the plant figured by Vittadini.

4. GEASTER LIMBATUS Fr.—Large. Outer peridium seven or eight lobed, the segments strongly reflexed but with incurved tips. Inner peridium brownish or gray, globose or somewhat depressed, raised on a short compressed slightly apophysate stipe. Mouth fimbriate, on a more or less evi-

dent disk. Spores less opaque and more finely granulated than in the last, 4 μ.—Pl. 1, f. 4.—Open woods. Wisconsin specimens collected by Bundy, also occur in the herbarium of Professor Peck.

Figures:—Morgan, *l. c.* 967, f. 6. *Exsiccatae:*—Ellis, N. A. Fungi, no. 1309.

Geaster bryantii, B., reported by Bundy in Rep. Geol. Surv. i, 399, presumably on specimens of *G. limbatus*, is similar, but with an elongated mouth plicate as in *G. Rabenhorstii*, and with a delicate cup at base of the stipe which, in typical specimens, is also surrounded by a hanging collar-like fold below the apophysis.

Geaster striatus (DC.), also recorded by Bundy, perhaps a specimen of *G. saccatus*, resembles that species in its general features, but the inner peridium is more or less stalked and the mouth plicate, while the outer peridium is not saccate at base.

Geaster triplex Jungh., which is represented in the Lapham herbarium by a specimen without date or locality, is recognized by a lacerated cup-like intermediate layer, which surrounds the base of the inner peridium. It should be observed that a similar but inconstant and much smaller middle peridium is occasionally seen in the *vittatus* form of *G. saccatus* as it occurs about St. Louis, and is figured in *G. hygrometricus* by Corda (Icones Fungorum, vi, pl. 4, f. 42, nos. 16-17).

Synopsis of Bovista.

Less than 1 in. in diameter; spores obovoid, long-pedicelled—*B. plumbea.*
Over 1 in. in diameter; spores globose, short-pedicelled—*B. pila.*

1. Bovista plumbea P.—Usually half an inch to an inch in diameter, irregularly globose or depressed when old. Peridium at first double, the outer layer dull white, flaking away, the inner white to lead-color or sometimes dark purplish gray or even nearly black when old, smooth and slightly glossy, dehiscent at the apex by a round or oblong fissure mostly with revolute margins. Capillitium deep chestnut brown, much branched, the twigs blunt. Spores brown, nearly smooth,[1] short obovoid, 5—6×6—7 μ, with colorless pedicels 2×17 μ.—Pl. 1, f. 5.—Very common in open hilly pastures; also sent from River Falls (*King*), and doubtless occurring everywhere.

B. plumbea and *B. nigrescens* are species readily confused if they are really distinct. I have as yet failed to convince myself that our larger, darker plants are more than a form of *B. plumbea.* Fries (systema, iii. 24) records both as American; but I have seen no specimens corresponding closely to *B. nigrescens* as figured in Berkley's Outlines of Brit. Fungology, pl. 20, f. 5. Sturms Flora Heft 18, pl. 15; Bolton's Funguses about Halifax, pl. 118; and Sowerby pl. 331. Our common form is well represented by Micheli, pl. 97, f. 6; Corda, Icones, v, pl. 6, f. 47, nos. 3-4 (the former inverted); Vittadini, Funghi Mangerecci, pl. 33, f. 1; Berkeley, *l. c.* pl. 20, f. 6; and Sturm's Flora. Heft 18, pl. 16 (copied by Winter). It is hard to see on what grounds Fries and Winter refer Batsch. pl. 29, f. 166 to *B. nigrescens.*

[1]The descriptions in this paper apply to spores that have not been much soaked in water, since the markings of many more or less completed disappear when the spores are wet, as the case of some Ustilagineæ and Uredineæ.

A small lead-colored specimen from Albany, N. Y., in the Curtis herbarium (*Peck*, no. 76), under this name has round nearly stalkless rough spores 5 μ in diameter, and is evidently a denuded plant of *B. circumscissa* B. &. C., not yet found in Wisconsin.

I can corroborate the assertion of Vittadini that this is one of the most delicate of edible fungi when gathered young and properly cooked. The first sign of discoloration, as with other puff-balls, marks it as too old for the table.

2. BOVISTA PILA B. & C., seldom less than an inch and a half in diameter, usually two or two and a half inches, irregularly globose or somewhat pinched in at the base, which often bears remnants of a myceliæ cord. Peridium with at most a very delicate flaking outer layer, typically smooth and glistening, grayish-buff, dark gray or blackish-purple, usually dehiscing late by an irregular fissure at no fixed point. Twigs of the capillitium wavy, tapering, chestnut-brown, paler toward the tips, fading to a decided pink in old weathered specimens. Spores nearly spherical, stalkless, 3, 5 — 5 μ, nearly smooth, paler than in the last.— Pl. 1, f. 6.— Abundant in wood-pastures, less frequent in open fields.

This species was originally described (Grevillea, ii. 49) from Wisconsin specimens collected by Lapham. I have seen other specimens from Sheboygan (*Brown*), Sparta and Middleton (*Miss Schuster*), Bloomingdale and La Crosse (*Pammel*), and have collected it in abundance at Weyauwega. In its nearly single peridium and irregular dehiscence, this is decidedly unlike typical species of *Bovista*. Like the last, it is excellent eating when gathered young and properly cooked.

Bovista ammophila, Lev., reported (perhaps on specimens of the last) from Wisconsin by Bundy (Rep. Geol. Surv., i, 399), has a similar cord-like base, but is distinguished by its spores, which, as figured by Lévéillé (Ann. Sci. Nat. Bot. 3 ser. ix, pl. 9, f. 5-6), are prominently obovoid and long-pedicelled.

B. subterranea, Pk., a depressed-globose species, which matures just below the surface of the ground, bulging it up at maturity; is recognized by its firm dull-brown inner peridium, half an inch to an inch and a half in diameter, opening by a small apical pore; its fleecy outer peridium, impregnated with dirt and evanescent above; and olive-purple capillitium and spores, the former flexuous and rather sparingly branched, the latter globose, stalkless, rough, 4 — 7 μ in diameter. This species, described from Dakota specimens, has been collected by me in Colorado, and comes from River Falls (*King*), so that it may be looked for at Madison, in sandy soil.

Mycenastrum spinulosum, Pk. (Bot. Gaz., iii, 170; vi, 240) a species of the Southwest which also occurs in the collection made by Dr. Brown at Sheboygan; is a gray puff-ball, irregular or kidney-shaped, measuring as much as four inches in its greatest diameter. It may be recognized by its smooth, almost woody, peridium, nearly one-sixteenth inch thick, at last breaking stellately, often with serrate edges to the lobes, and by its purple-

brown spinose capillitium and rough, opaque, paler spores 10 to 12 μ in diameter. It differs from the European *M. Corium* Desv. (also found in Arizona and Colorado) in its decided purple color when freshly broken. I have been able to test this latter species in Colorado, and find it palatable.

SYNOPSIS OF LYCOPERDON.[1]

Plants large; peridium flaking away irregularly at top.
- Sculptured and somewhat furfuraceous when young ..... *L. favosum.*
- Not sculptured, mostly glabrous; very large ..... *L. Bovista.*

Small or medium-sized; opening by a pore at apex.
- Spores brown, yellowish, or olive, smooth or minutely roughened.
  - Shaggy or with deciduous spines.
    - Spores long-pedicelled ..... *L. pedicellatum.*
    - Spores stalkless.
      - Fleecy, sessile; old peridium not pale-areolate; growing in meadows and grass land ..... *L. Wrightii.*
      - Warty, the larger spines deciduous, leaving pale round dots; growing in the woods ..... *L. gemmatum.*
  - Smooth, or at most scurfy, (rarely sub-shaggy, in *L. pyriforme?*).
    - On rotting wood; gregarious; mostly stalked, with creeping white fibers ..... *L. pyriforme.*
    - On the ground; not gregarious.
      - Spores ellipsoidal ..... *L. oblongisporum.*
      - Spores round or slightly obovoid.
        - Peridium not dark-dotted, often mealy-scurfy.
          - Sessile; usually under three-fourths inch ..... *L. pusillum.*
          - Often stalked; larger ..... *L. molle.*
        - Peridium dark-dotted when mature; sessile ..... *L. coloratum.*
- Spores more or less red-purple, rough-warty.
  - At first spinulose or shaggy.
    - Spines very long, white, all deciduous ..... *L. pulcherrimum.*
    - Spines shorter, buff or brown.
      - Mature peridium mealy-roughened, but glossy ..... *L. atropurpureum.*
      - Not mealy; reticulated with small brown warts ..... *L. constellatum.*
  - Not at all shaggy.
    - Reticulately furrowed; somewhat flesh-colored ..... *L. rimulatum.*
    - Not furrowed; buff ..... *L. glabellum.*

1. LYCOPERDON FAVOSUM (Rostk.).—Three to six inches in diameter, four to five inches high, depressed, spherical with a stout conical base, marked with coarse angular depressions, the pale fleecy outer peridium cracking so as to expose the brown inner layer, in anastomosing lines. Spores and capillitium, snuff-color or greenish-brown, liberated by the breaking away of the thick but fragile peridium. Spores slightly obovoid, nearly smooth, stalkless, $4.25-4.5 \times 4.5-5\ \mu$.—Pl. 1, f. 9.—Grassy fields, late summer and autumn.

[1] Since the preparation of this paper, which was presented to the Academy in 1884, two important publications on Lycoperdaceæ have appeared, namely: a revision of the genus *Lycoperdon* by Massee (Trans. Roy. Microsc. Soc. 1887, 701), and the compilation of the entire group by De Toni, for the seventh volume of Saccardo's Sylloge Fungorum. So far as possible, these have been consulted in a final revision of the manuscript for publication. —May 10, 1888.

I have had some doubt as to whether this plant, collected but once, should be referred to *L. favosum* or *caelatum*. The latter species is reported by Bundy (Rep. Geol. Surv. Wis. i, 399) and Peck (U. S. species of Lycoperdon, 12), from Wisconsin, and I have seen unmistakable specimens of it from this state in the herbarium of Professor Peck, while it appears to be pretty frequently met with in the west.

2. LYCOPERDON BOVISTA L. (L. giganteum of most authors).—Seldom under ten inches in diameter, often very much larger: smooth, or at least not floccose-sculptured nor pitted like the last. Peridium less corky, flaking away in thinner more papery layers, spores and capillitium yellower, the latter not separating from the sterile base. Spores nearly globose, almost smooth, 4 to 4.5 μ.—Grass land in late summer and autumn. Also reported from Wisconsin by Bundy (*l. c.*).

Figures: — Palmer, Mushrooms of America, pl. 8, f. 1.

Lycoperdon cyathiforme, Bosc., which occurs in the Curtis herbarium from Wisconsin (*Sprague*, 1169, Coll. *Lapham*), has been collected at Sheboygan (*Brown*), River Falls (*King*), and La Crosse (*Pammel*), and is also mentioned by Bundy (*l. c.*), is a stout pear-shaped or depressed-globose puff-ball approaching *L. callatum* in size, but easily distinguished by its smoother but areolated outer peridium, flaking away near the top as a thin papery layer, revealing the thicker fragile purple inner layer, and by its round finely granulated very purple spores, 4.5 to 6 μ in diameter. The sterile base persists for a long time, and is what Bosc's description (Mém.s. quelques espèces de champignons des parties mérid. de l' Amér. Sept., 5-6, pl. 6, f. 11) and figure were taken from. The American plant is not distinct from that which Vittadini[1] at first referred to *L. Bovista*, but afterward called *L. fragile*.

These three species are esteemed for food, whereas most of the smaller species of the genus have a disagreeable flavor. On this subject see Peck, U. S. Sp. of Lycoperdon, 7; 32 Rep. N. Y. Museum, 62; Country Gentleman, November 5, 1885; Palmer *l. c.*; and a note by myself in St. Nicholas, September, 1886; as well as Badham and other European writers on edible fungi.

3. LYCOPERDON PEDICELLATUM Pk.—Depressed globose to obovoid or sub-pyriform, usually one to two inches in diameter, with coarse angular or slender stellately united spines, a minutely granular darker recticulum between their bases. Denuded peridium, dull pinkish or buff, with round or polygonal depressions corresponding to the insertion of the fallen spines: base granular with more or less persistent coarse warts. Spores olive-yellow, slightly obovoid, minutely granular, 4-5 $\times$ 5-6 μ, with slender nearly colorless pedicels 18 to 25 μ long.—Pl. 1, f. 7.—Found once on the ground in open woods; received from River Falls (*King*); and locally abundant elsewhere, often in open places.

It has frequently been asserted that the spores of *Lycoperdon* are stalkless while those of *Bovista* are pedicelled. Understanding stalkless to mean (as in this paper) with a pedicel not exceeding 1 μ in length, this generaliza-

[1] Funghi Mangerecci, 263-8, pl. 33, f. 2. See, also, Berkeley, Notices of N. A. Fungi, no. [illegible].

tion is not true. *L. cepaeforme* and *L. Hongkongense*, like the present species, have their spores permanently stalked. The sterigmata of the group with red-purple spores (nos. ——) are at first very long, and they are also sometimes subpersistent. On the other hand the spores of a number of species referred to *Bovista, e. g. P. pila, B. circumscissa*, and *B. tosta*, are not pedicellate.

4. LYCOPERDON WRIGHTII B & C.— Round or broadly pear-shaped, often gregarious and more or less angular from mutual pressure; three-eighths to three fourths inch in diameter; densely covered with short grouped white spines that are buff and deciduous at maturity, exposing the pubescent or nearly smooth, dirty straw colored or buff inner peridium. Spores and capillitium pale greenish buff, the former finely granular, round, stalkless 3.5 to 4.25 μ. — pl. 1, f. 8.— Very abundant at the sides of paths and on open, bare places in dry, closely cropped grass land.

Specimens have also been sent me from River Falls (*King*), Sheboygan, (*Brown*), and Sparta (*Miss Schuster*), and the species is reported by Bundy in the list already referred to.

Lycoperdon cruciatum Rostk. (*L. separaus* Pk., *L. Wrightii*, var. *separaus* Pk.), of which doubtful immature specimens have been collected about Madison, and which Miss Schuster sends from Sparta, and Professor King, from River Falls, occurs more commonly in shaded places and is distinguished by its somewhat large size (half an inch to two inches) and more clay-colored or darker spores which are often pedicellate or intermingled with fallen sterigmata 5 to 7 μ long; and especially by the (very soft and flexible often dark brown) velvety inner peridium, from which the closely united white spines flake away in a continuous layer. The American plant corresponds well with the figure of Rostkovins (Sturm's Flora, Heft. 18. pl 8), though its spines are more crowded than in the figure. If the last runs into this, the name of Rostkovins must have precedence.

5. LYCOPORDEN GEMMATUM Batsch.— Usually gregarious, one to two inches in diameter, sometimes as much as three inches high, commonly top shaped, the fertile pair contracting into a stout obconic stem which equals or surpasses the enlarged summit in length, white, passing into pale buff or gray; with fleshy deciduous warts and intermingled more persistent smaller ones. Spores pale brown, thin-walled and translucent, finely granulated, round, stalkless, 3.5 to 4.5 μ.-Pl. 2, f. 1. Very abundant on the ground or occasionally on decayed wood, in the woods.

The Lapham herbarium contains specimens from Milwaukee, and I have seen others from Sheboygan (*Brown*). Bundy also reports the species. The most characteristic feature of this, which is one of our commonest species, is the occurrence of solid fleshy warts, often one-sixteenth of an inch or more in length, which stud the upper part of the peridium, giving it an appearance of great beauty when young. These are easily removed, leaving round, pale spots, one-thirty-second to one-sixteenth inch in diameter, on the peridium, elsewhere covered with fine granules. Even on old weathered specimens when the latter have entirely disappeared from the top, the characteristic pale spots are to be found toward the base.

Figures:— Palmer, Mushroons of America, pl. 8; Trelease, St. Nicholas, xiii, 875, f. 4. *Exsiccatae:*— Ellis, N. A. Fungi, no. 1,699.

6. LYCOPERDEN PYRIFORME Schaeff.—Our most variable species, globular, pear-shaped, or clavate, sessile or stipitate, usually five-eighths inch to an inch in diameter, and half an inch to an inch and a half high (exceptionally as much as one and one-fourth by two inches). Peridium buff, covered with uniform persistent coarse dark brown granules (exceptionally with substellate short spines?). Spores pale olive, smooth, round, 3.5 to 4.5 μ stalkless.—Pl. 2, f. 5. Very common in woods, on old stumps, buried sticks, etc., the plants commonly gregarious, and connected by coarse white fibers.

I have also examined specimens collected at Sheboygan (*Brown*), and River Falls (*King*), and others occur in the Lapham herbarium. Bundy also mentions the species in his list of Wisconsin fungi.

Exsiccatae:— Ravenel, Fungi Carolin., ii. no. 72; Fungi Amer., no. 469.

7. LYCOPERDON OBLONGISPORUM B. & C.—Round to broad, pyriform, three-eighths in. to 1 in., usually narrowed below, with a mycelial cord at base. Peridium brown, at first furfuraceous, finally glassy, but with minute persistent granules. Spores greenish-brown, almost smooth, ellipsoidal, stalkless, $4 \times 6\ \mu$.—Pl. 2, f. 3.—Rather abundant on the bare ground in dense woods; August.

This pretty species, previously known only from Cuba,[1] is indistinguishable from the next when immature, the spores affording the only really characteristic feature. It has probably been overlooked in the past chiefly for this reason and because the mature plants, from their leaf-brown color, are not at all conspicuous. *L. Hongkongense* B. & C. (N. Pacific Expl. Exped. Fungi,—Proc. Amer. Acad. 1858,—124, no. 119), as I find from an examination of original specimens in the Gray herbarium at Cambridge, is a little more elongated than this species but with the same microscopic characters otherwise. Its spores, however, differ in being long-pedicelled. In their memoir on *Lycoperdon* and *Scleroderma* (Ann. Sci. Nat. 1842, Ser. 2, xvii, 13–14, Pl. 2, B. f. 5–7) the Tulasnes figure pedicellate oblong spores for some plants of *L. cepaeforme* Bull., which is referred to as synonymous with *L. pusillum* Fr. and *L. ericetorum* P.

8. LYCOPERDON, PUSILLUM Fr.—Microscopic characters of the preceding, but usually paler and less glistening when mature. Spores round or barely obovoid, nearly stalkless, 3.5 to 4.5 μ, evanescently minutely roughened or smooth.—Pl. 2, f. 4.—Rather frequently on the ground, in open fields; also sent from River Falls (*King*), and reported by Bundy (*l. c.*)

Exsiccatae: Ravenel, Fungi Carol. ii, no. 73; Fungi Amer. no. 138.

9. LYCOPERDON MOLLE P.—Depressed, globose, half an inch to an inch and a quarter in diameter, sessile or on a stipe of equal length. Peridium cream-color passing into buff, mealy-furfuraceous, glistening when old. Spores olive, round, stalkless, minutely echinulate, 3.5 to 5 μ.—Pl. 2, f. 6.

On the ground in open woods and pastures; also collected at River Falls (*King*).

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[1] Berkeley & Curtis, Fungi Cubenses (Journ. Linn., Dec., 1867), 345, no. 505.

This species superficially resembles small plants of *L. glabellum* Pk. so closely that it is difficult to distinguish them. When cut open, especially if gathered immature and allowed to ripen in the laboratory, it sometimes also presents a red-purple section; but this does not depend upon the color of the spores, which afford constant and certain means of distinguishing the two species, since in this they are about as in *L. gemmatum*, while in *L. glabellum* they are nearly as in *L. constellatum* or the related species of the purple-spored section.

10. LYCOPERDON COLORATUM Pk.— Round, and somewhat depressed and contracted at the base, three-eighths to one inch; from pure white passing into yellowish and at maturity buff; granular-mealy; finally glistening and dotted with minute dark granules that persist or often rub away from large areas. Spores and capillitium buff, the former paler, round, smooth, stalkless, 4 to 5 μ.— Pl. 2, f. 2.— On the ground in damp woods; August.

11. LYCOPERDON PULCHERRIMUM B. & C. (*L. Frostii* Pk.)— Obovoid, an inch to an inch and a half in diameter and about as high. Peridium coffee-color at maturity, covered with very deciduous slender white spines, often three-sixteenths inch long, clustered by their tips; usually smooth and glossy after their fall. Capillitium at last red-purple, spores varying from pale buff to reddish-purple, round, with very low colorless warts, nearly stalkless, 4 to 6.5 μ.— Pl. 3, f. 1.— Open grass land, not uncommon.

In this and other species of the purple-spored Proteoids the pedicels of the spores, even in mature specimens, are sometimes 2 to 4 μ long, whereas in other groups the species that have not long pedicelled spores very rarely show pedicels much over 1 μ long.

The spores of the group of species which follows are very uniform, coarsely warted and usually short-stalked. As shown by Peck (U. S. species of Lycoperdon, 18), they are intermingled with fragmentary colorless rods, to which they are not attached, but that represent the fallen remnants of long sterigmata, as may be seen by examining young specimens. In this paper (p. 22) and in 32 Rep. N. Y. Museum, p. 68, Peck states that *L. pulcherrimun* B. & C. is evidently the same as *L. pedicellatum* Pk., an opinion which I shared until, in looking through the puff-balls of the Curtis herbarium, which Dr. Farlow obligingly placed in my hands, I found the type of *L. pulcherrimum*, gathered in Pennsylvania, in 1852, and preserved under the number 3933. The description by Berkeley (Notices of N. A. Fungi, 50, No. 336,— Grevillea, ii, 51) is certainly more applicable to *L. pedicellatum* than to this species, especially as regards the size and color of the spores; but unless two entirely different things were collected under this number, so that Berkeley's description was not drawn up from a duplicate of the Curtis type, there can be little doubt that *L. Frostii* and not *L. pedicellatum* is a synonym of *L. pulcherrimum.*

12. LYCOPERDON ATROPURPUREUM Vitt.— Extremely variable in size and form, three-fourths to two and one-half inches in diameter, one and one-fourth to three inches high, obconical or pyriform to subglobose; nearly

sessile or on a long stipe. Peridium straw color or dull buff, nearly spineless or with sharp, dark spines, often united in clusters by their tips, furfuraceous with a more or less evanescent mealy coating through which the inner layer appears glossy. Spores purple-brown, coarsely granular, round, 4.5 to 6.5 μ, nearly stalkless or with pedicels 2 to 4 μ long.— Pl. 3, f. 2.— Rather frequent on the ground in bushy woods, or occasionally on decaying wood. Reported by Bundy, and occurs from Wisconsin (*Lapham*) in Hb. Curtis as *L. saccatum*. The more spinose form is var. *hirtellum* Pk.

Though easily recognized in most of its forms, this is one of the most perplexing of our species. Berkeley and Curtis as well as Dr. Winter, who examined some of our specimens, have considered the plant to be *L. saccatum* Fr. As *saccatum* is understood by Bouerden (Bot. Zeitung, 1857, 596), and Winter (Rabenhorst's Kryptogamen-Flora, i, 901), this determination is unimpeachable; but *L. saccatum* of Fries and the Flora Danica (Pl. 1139), has a flaking peridium similar to that of *L. bovista* and *L. cyathiforme*, whereas our plant possesses a persistent peridium opening by a terminal pore. Recognizing this, Winter (*l. c.*) admits that Bouerden appears not to have possessed the true species of Fries, yet does not hesitate to follow him. The real *saccatum*, which occurs in New York, is certainly very distinct.

Figures:— Palmer, Mushroons of America, pl. 8, as *L. saccatum*. *Exsiccatae:*—Ravenel, Fungi Carolin., iv, no. 73, in part, as *L. gemmatum*.

13. LYCOPERDON CONSTELLATUM Fr. Subglobose or more commonly in the form of an oblate spheroid, somewhat pinched-in at base, one to two inches in diameter. Peridium straw-color, gray or copper, at first with deciduous brown spines clustered by their apices, and intervening low brown warts that persist as a prominent reticulum, or, ultimately falling, leave the peridium minutely facetted, somewhat resembling "hammered work" in metal. Spores nearly as in the last, 5 to 6.5 μ. Old capillitium brown.— Pl. 3, f. 4.— On the ground in bushy woods.

Though more depressed than *L. umbrinum* of the Flora Danica (pl. 1800), which is the prototype of *L. constellatum*, our plant agrees so well with the descriptions, that I have followed Peck in referring it to that species. According to Dr. Winter, it nearly resembles *L. capricum* Bouerd.

14. LYCOPERDON RIMULATUM Pk. in herb.— Depressed globose, pinched-in and radicating at base, slightly umbonate at apex, three-fourths to one and one-half in. in diameter. Peridium tawny flesh-color, thin, glabrous, rimulate with anastomosing furrows. Spores red-purple, rough-warty, 5 to 6.5 μ; their pedicels 2 μ or in immature specimens, as much as 15 μ long.— Pl. 3, f. 3.— On the ground in open wood pastures; September; also collected at River Falls (*King*).

An interesting plant, related to the *constellatum* group in its spore characters, but differing from our other species of this group in the absence of a spinose or mealy coating, the outer peridium merely cracking along the grooves as in *L. caelatum*. I am indebted to Mr. Peck for the name employed, which he has applied to immature specimens in his herbarium, from Ohio (*Morgan*) and New York.

15. LYCOPERDON GLABELLUM Pk.—Depressed globose, or elongated and stipitate, more or less umbonate, three-fourths to two in. high. Peridium buff, very finely furfuraceous. Spores and capillitium purple or more or less brown, the former 5 to 6 μ, with coarse warts, and short-pedicelled.—Pl. 3, f. 5.—On the ground in woods, accompanying *L. gemmatum;* River Falls (*King*).

Tulostoma fimbriatum Fr., a small puff-ball raised on a solid cylindrical stipe about one-eighth in. in diameter and as much as an inch long, may be recognized by its subglobose more or less granulated peridium, opening by a small scarcely protruding fimbriate mouth, brick-colored, remotely spinose, round spores 4-5 μ in diameter, and pale blunt anastomosing capillitium. I have received it in quantity from Professor King, of River Falls.

SECOTIUM.

1. SECOTIUM ACUMINATUM (Mont.) (*S. Thunii* Schulzer. *S. Warnei* Pk.)—Short stipitate, subglobose to conical ovoid, rounded or frequently more or less acuminate above.

Peridium rather leathery, dull yellowish-white, passing into buff; smooth or mostly with crenated scale-like elevations often free at their lower edge, dehiscing irregularly about the stipe, which is prolonged through the sporiferous portion as a stout columella one-fourth to one-half in. in diameter, and firmly united with the peridium at apex. Spore-bearing mass snuff-brown, extending laterally from the columella in a series of eroded friable thin gills. Spores yellow-brown, smooth, stalkless; extremely variable, spherical, ellipsoidal, or more or less regularly ovoid, 4-9×6-14, most commonly 6×8 μ.—Pl. 2, f. 7.—Abundant in late summer and fall in open pastures, etc. My largest specimens were obtained on the bare ground in a potato patch.

Reported from Wisconsin by Bundy (*l. c.* 399,—the specimens preserved in hb. Peck), and Peck (Bull. Torrey Club), and included in the collections of Dr. Brown, of Sheboygan, and F. H. King, of River Falls. Edible when young.

According to Schulzer von Muggenburg (Hednigia, 1883, 43), this species, described by Peck. as *Lycoperdon Warnei* (Bull. Torrey Bot. Club, vi, 77), *Podaxon Warnei* (U. S. Sp. Lycoperdon, 34), and *Secotium Warnei* (Bull. Torrey Cl. ix, 2), is identical with the European *S. Threnii* Schulzer, which is referrible to *S. Acuneinatum* (Mont.) Tul. *S. Szabolcsense* Hasl., judging from his figure and the abstract of his paper in Jost's Bot. Jahresbericht for 1876, p. 161, must be extremely closely related.

Figures:—Peck. Bull. Torry Bot. Club, ix. pl. 9, f. 6-11; Revue Mycologique, iv. pl. 16. f. 13.

SYNOPSIS OF SCLERODERMA.

Peridium thin, dark-dotted — — — S. verrucosum. More conaceous, uniformly colored, usually furrowed or sculptured.— . *S. vulgare*.

1. SCLERODERMA VERRUCOSUM (Vaill.) — Flattened biscuit-shaped, ¼ to 1¼ in. in diameter, nearly sessile or with a short stipe, radicating at base. Peridium thin and flexible above, but tough; yellowish buff, a thin outer layer cracking during development and persisting as small angular darker scales; dehiscence irregular, apical, spores purple, roundish, stalkless, sharply echinulate, 8 to 10 μ.— Pl. 3, f. 7.— One of the earliest and commonest of our puff-balls, on the bare ground in roads. I have also collected specimens above Kilbourn City, and the species is found at River Falls (*King*) and is named in Bundy's list.

Neither this nor the following species is considered fit for food,[1] though greedly devoured by snails. Even the young plants emit a disagreeable pungent odor, quite different from that of other puff-balls.

This is, at least in part, *S. Bovista* of Ellis, N. A. Fungi, no. 24; and, perhaps, of Von Thuemen. Mycotheca Universalis, no. 607,— both from New Jersey, but in my own copy of the Mycotheca, and in Dr. Farlow's, the latter number appears to be a form of *S. vulgare*. Our plant is that figured by Nees (Syst. du Schwämme, pl. 11, f. 124) under the name *Bovista plumbea*, obviously an error. It is not evidently different, except in the shortness of its stipe, from *Lycoperdon verrucosum*, *sphaericum*, etc., of Vaillant (Bor. Parisiense, pl. 16, f. 7), *L. verrucosum* of Bulliard (Pl. Vénén. de la France, pl. 24), *L. defossum*. Sowerby (British Fungi, pl. 311), and *Scleroderma verrucosum*, Greville (Scot. Crypt. Flora —, pl. —). It is also quite similar to that figured by Sorokine (Ann. Sci. Nat. 6 ser. iii. pl. 6 f. 12 f.) as *S. verrucosum*, and agrees in all essentials with a French specimen in the Curtis herbarium referred to *verrucosum* by Desmazieres. The transparent border to the young spores, figured by the Tulasnes (Ann. Sci. Nat. 2 ser. xvii. pl. 1, A. f. 8) in what they doubtfully refer to this species, and which I have noticed in *S. vulgare*, f. *minor* of Saccaede's Mycotheca Veneta. no. 1412, has not been observed by me in American specimens of either species; but is held by Caspary (Sitzber. Geo. zu Konigsberg, 1886, xxvii, 203) to be merely an immature character.

2. SCLERODERMA VULGARE Fr.— Depressed globose, narrowed and radicating below, three-fourths to two in. in diameter. Peridium pinkish or buff, thick, smooth or finely checked by intersecting dark furrows about one-sixteenth in. apart. Spores as in the last, nine to fifteen μ, the spore-mass when maturing separated into small grains by bundles of pale gray hyphæ.

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[1] *Scleroderma vulgare* is commonly held to be poisonous to man, but according to Smith (Gard. Chron. 1885, 48) and Caspany (Schrift. Physik.— Ockonom. Gesellsch zu Königsberg, xxvii, 109; Bot. Centralblatt, xxx, 34), it is collected in parts of England and Germany as a truffle and eaten after cooking, without known ill effects. But its bad name should be borne in mind by anyone desirous of experimenting with it.

—Pl. 3, f. 6.—Grass land or in mossy dry woods. Also sent me from Sparta (*Miss Schuster*) and River Falls (*King*), and reported by Bundy.

Our Western form, as I have seen it at Madison and about St. Louis, is often smooth except for the simulate areolation referred to, in this respect differing from a common Eastern and European form, which is also decidedly yellow, but it is undoubtedly a form of the same polymorphic species. The *S. verrucosum* of Bundy's list is presumably the rougher plant, which is shaggy with coarse scales, often free and recurved above.

Scleroderma Bovista Fr., named in Bundy's list, differs from *vulgare* in its thinner peridium, and from both of the preceding species in the more olive spore-mass with intermingled yellow flocci; otherwise it closely resembles *S. vulgare*, from which, like Caspary (*l. c.*, 204), I often find it hard to separate it.

Elaphomyces, one of the Tuberaceae, developing underground, when mature resembles a *Scleroderma:* but its spores are borne in asci that are evident in young plants. We have as yet found no representative of this genus, which should be looked for in pine woods, etc.

EXPLANATION OF PLATES.

The plants are represented of the natural size, and their spores uniformly enlarged 2000 diameters.

PLATE VII.

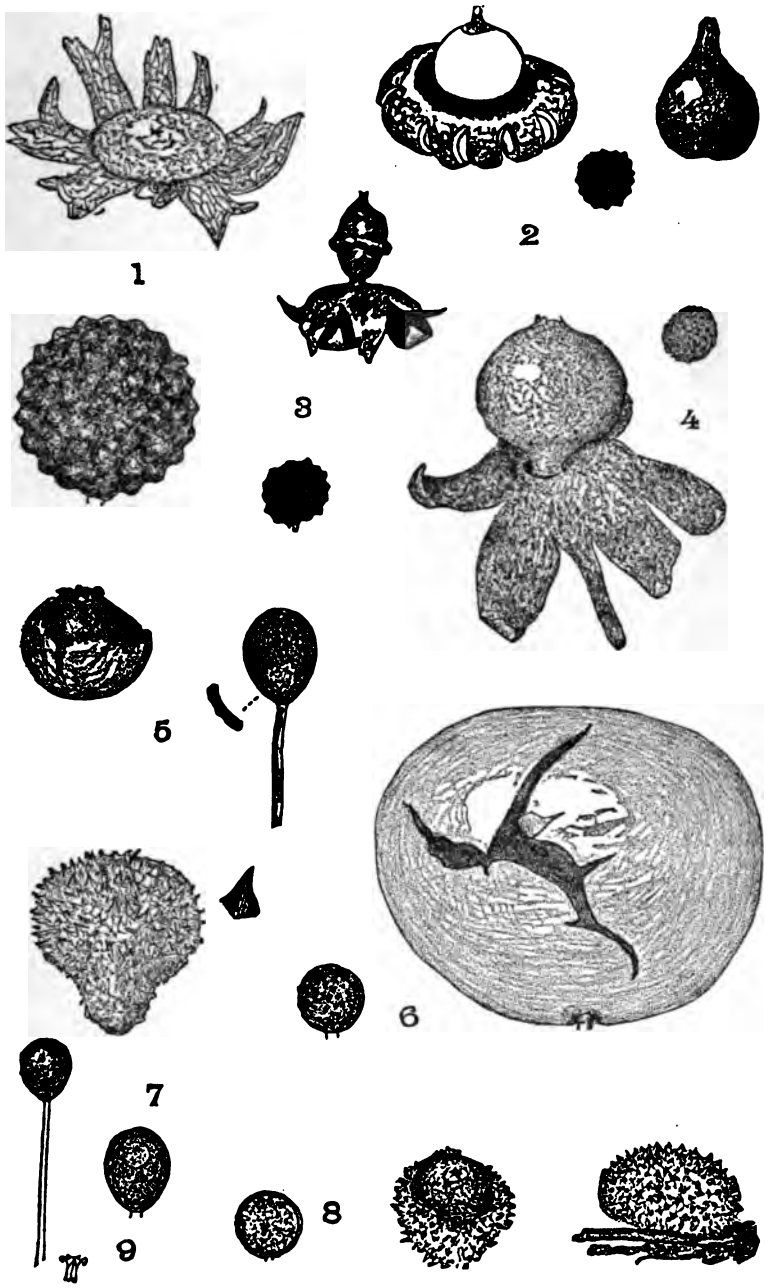
1, Geaster hygrometricus and spore; 2, G. saccatus and spore; 3, G. Rabenhorstii and spore; 4, G. limbatus and spore; 5, Bovista plumbea and spore; 6, B. pila and spore; 7, Lycoperdon pedicellatum (small specimen) and spore; 8, L. Wrightii, two plants and spore; 9, spore of L. caelatum.

PLATE VIII.

1, Lycoperdon gemmatum and spores; 2, L. coloratum and spore; 3, L. oblongisporum and spore; 4, L. ericetorum and spore; 5, L. pyriforme and spore; 6, L. molle and spore; 7, Secotium acuminatum, in section, and spore.

PLATE IX.

1, Lycoperdon pulcherrimum and spore; 2, L. atropurpureum, three plants and spore; 3, L. rimulatum and spore; 4, L. constellatum (?) and spore; 5, L. glabellum and spore; 6, Scleroderma vulgare and spore; 7, S. verrucosum,—subsessile and stipitate forms.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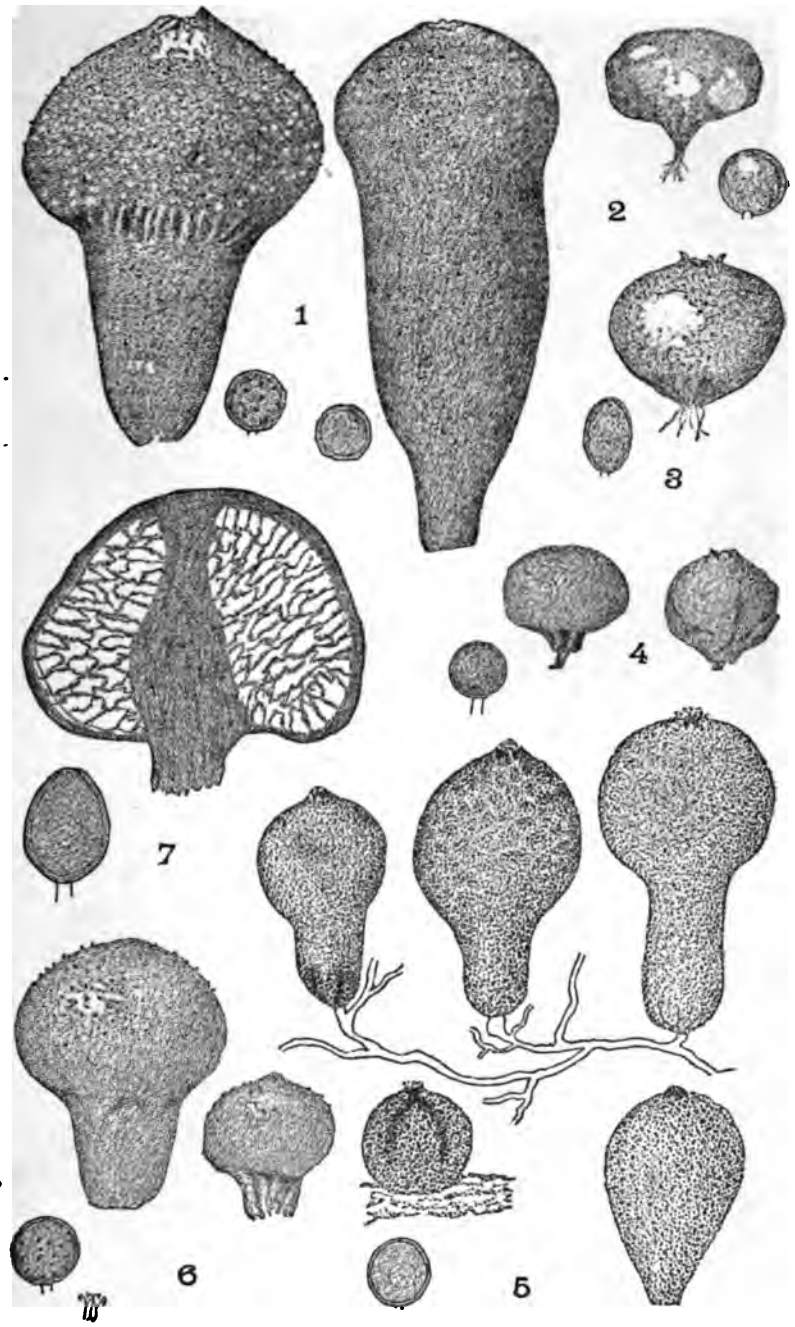
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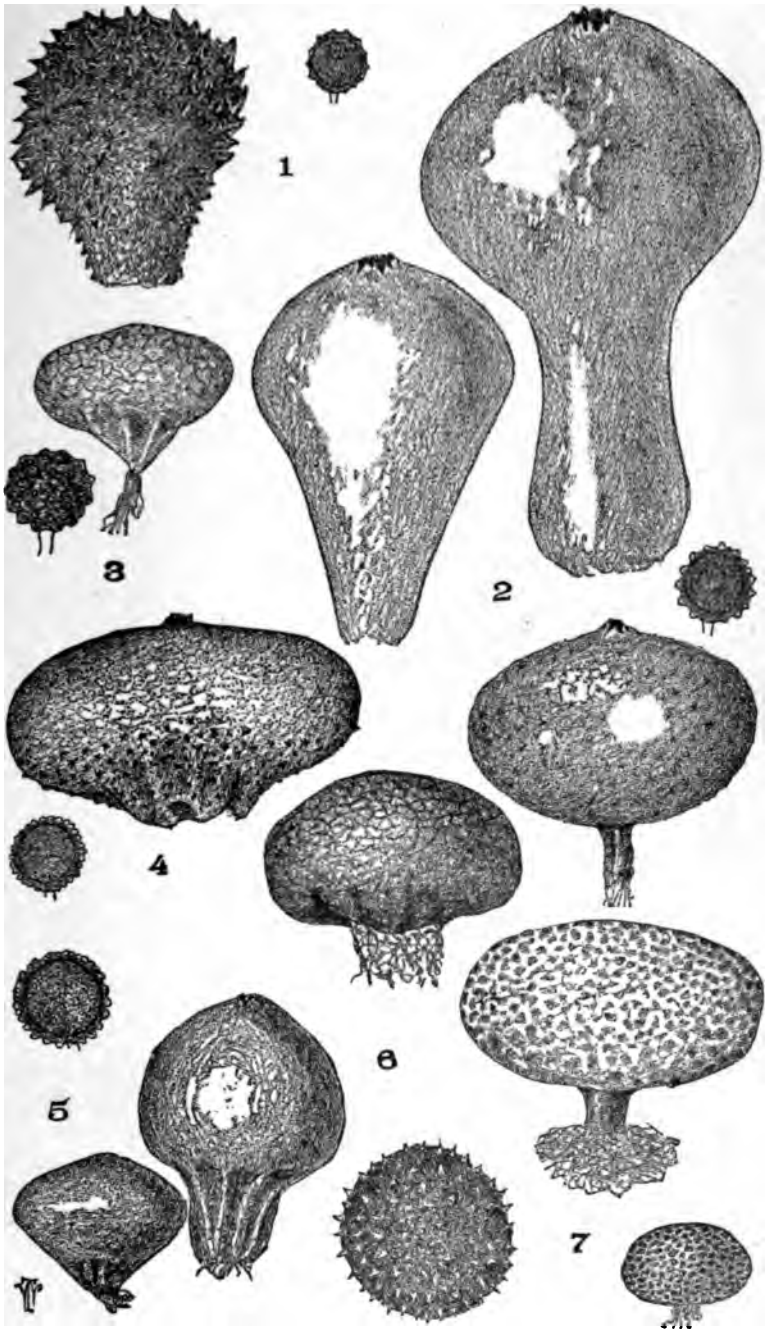
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THE "WORKING" OF THE MADISON LAKES.

BY WILLIAM TRELEASE.

Every season a greenish-yellow scum occurs in greater or less quantity on Third and Fourth Lakes (Mendota and Monona), during the hot weather of summer, after the water has been calm for a number of days in succession. When but little of it is present, it appears as fine granules suspended in the water, often scarcely visible to the naked eye except as they reflect the light, when they call to mind the dancing motes in a beam of sunlight. Under the influence of a gentle, but continuous breeze, these particles are collected into fleecy masses, and driven ashore, so that they accumulate along the margin of the lake, forming a slimy scum which quickly putrefies, giving off a very disagreeable odor. During this change, its color changes to a decided blue-green, which stains the pebbles, sticks, etc., over which it is smeared. The appearance of this scum is sometimes spoken of as the working of the lakes, from a resemblance to the collection of a scum on cider, etc., when fermenting, or, as an American idiom expresses it, "working."

Usually the scum is seen in small quantity and only attracts attention for a day or two at a time, in midsummer, when it collects on the city side of the lake; for a change in the direction of the breeze, or a brisk wind from any quarter usually scatters it in a short time. In the summer of 1882, however, the working of the lakes was noticed early in June, and on the 17th of that month enough scum had collected along the city shore of Fourth Lake to prevent boating. The odor which it gave off was noticeable at a distance of one or two blocks from the water. After a few days a change in the wind brought relief for a time, but the trouble was renewed at frequent intervals until the middle of November. The first formation of this scum was apparently traceable to the long, shallow bay between Picnic and Second Points, in Fourth Lake, and to the bay at the west end of Third Lake, from which it was scattered by winds, and afterward increased everywhere.

In the summer, during calm weather, the water within a foot or two of the surface was everywhere filled with the minute granules already referred to. In places where counter currents met, as off Picnic Point, these were collected in a local surface film. While this appearance lasted the fish in the lake bit very little. On several occasions white bass were found in large schools

off the points, jumping under films of this nature, apparently at the glistening air-bubbles which were entangled at the surface; but though the entire range of the fly-book was tried, they persistently refused the hook. In other parts of the lake where there was little scum, the fish, especially pickerel, bit more freely.

The floating bodies, which at times are as large as pin heads, have once or twice been noticed as a cause of the dispersion of sunlight in a beautiful manner. One calm, bright morning in the fall, a student while rowing, observed a spectrum on the surface of the lake, which took the form of a parabola, with its vertex at his boat. To another person on shore, the spectrum appeared nearly straight. The appearance was of the same nature as the rainbow, and was apparently caused by refraction in the floating dots, which slightly projected from the smooth surface of the water, that covered them with a thin film. A breeze quickly ended it.

The working of the lakes at Madison corresponds to what is known in parts of Great Britain as the "breaking" of small bodies of water. On the continent, a similar scum is spoken of as water-bloom (Wasserblüthe, Fleur d' eau, Flos aquæ). In all these cases, the phenomenon depends upon the multiplication of minute algæ belonging to the group Cyanophyceæ, which usually accumulate suddenly and often disappear after a few days, either temporarily or for the balance of the season. Sometimes the bloom is said to disappear at nightfall, in quiet water, to re appear the next morning. The futility of fishing at such times is generally recognized in Europe, the common impression being that the fish are then sick. In this connection it may be said, however, that the wholesale death of fish, especially perch, in Fourth Lake, during the summer of 1884, and the death of numbers of whitefish every summer has apparently no connection with the water bloom.

Thuret divided the Cyanophyceae into Chroococcaceae and Nostochineae; the former with their cells not in chains; the latter with their cells placed end to end, forming filaments. The Nostochineae have since been separated into several groups equivalent to the Chroococcaceae, but for our purpose the simple division into the two main groups may be retained.

Of the Chroococcaceae, two are pre-eminent as forming water bloom:—*Clathrocystis aeruginosa* and *Coelosphaerium Kützingianum*. The principal part of the scum first collected at Madison consisted of the former species (Fig. 8), though the latter (Fig. 7) was also present.

What have usually been called *Anabaena flos aquae* and *A. circinalis* are, in their several forms, the commonest of the Nostochineae that occur under similar circumstances. A small part of the Madison scum of 1882 was composed of sterile plants apparently of *A. flos aquae*, which, with a little of a smaller *Anabaena*, occurred intermingled with the *Clathrocystis* and *Coelosphaerium*. These species lasted through the summer, the scum which they formed also containing not infrequent threads of *Lyngbya nollei* (Fig. 6), a few stellate plant hairs, and scattering grains of pine pollen. As the

season advanced, the larger *Anabaena* became relatively a trifle more abundant, but for the most part remained sterile.

Examinations were not made for several weeks in August and September, but on the 26th of September, when another sample was taken for the use of a laboratory class, the bloom consisted exclusively of the smaller *Anabaena* (Fig. 5), which I have called *A. mendotae*,[1] a species that continued to appear on the shore at intervals until well into November.

M. Bornet, who was obliging enough to examine specimens of this alga for me, writes as follows: "The *Anabaena* you have sent me belongs to the sub-genus *Dolichospermum* Thwaites, in the sense in which it is understood by Wittroch (Wittroch and Nordstedt: Algæ exsiccatæ, No. 496). It appears to me new, and differs from all of the species which constitute water-bloom in the tenuity of its threads, in the length of its articles and the slenderness of its spores. It is only comparable to *Limnochlide flos aquae* in the dimensions and configuration of the different vegetative and reproductive organs. That you may compare it, I send a tracing from analyses of authentic specimens of *Nostoc flos aquae* Lyngbya [Fig. 1], *Nostoc flos aquae* Agardh [Fig. 2], and *Anabaena circinalis* Rabenhorst [Fig. 3], which is the prototype of the species. Admitting that these three plants are but forms of a single species, as may be inferred from the observations of Wittroch on *Anabaena (Dolichospermum) hassallii*, your alga still differs from all of them, and is, especially, very distinct from the *Anabaena circinalis* of Rabenhorst."

As a general thing, protracted heat precedes the appearance of the water-bloom, which is most frequent in sluggish or stagnant bodies of water, especially such as are fed by the outlets of bogs, hence the phenomenon is most frequently noticed in mid-summer or later: yet the abundance of the scum in June 1882, shows that a very short period of warmth may suffice for its formation, as the early part of the spring was cold, and there had been but few hot days when it appeared.

Unlike the majority of the algæ implicated, *Limnochlide flos aquae* thrives exceptionally well in cold water, and has even been found luxuriating in the greatest abundance in ice.[2] *Anabaena mendotae*, which first became really abundant after the disappearance of *Clathrocystis coelosphaerium* and the larger *Anabaena*, and lasted until not only the air but the lake itself had become quite cold, appears to resemble it somewhat in this respect.

During the summers of 1883 and 1884, I was absent from the city, but I

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[1] *Anabaena (Dolichospermum) mendotae*, n. sp.—Threads circinate. Vegetative cells slender, usually elongated, especially towards the ends of the filaments, 3-4 × 4.5-12 μ. Heterocysts ellipsoidal or barrel-shaped, 4.5 × 6-7.5 μ. Spores remote from the heterocysts slender, more or less curved, 4.5-7.5 × 20-40 μ, bluish-green, like the vegatative cells (Fig. 5) Forming a copious water-bloom on Lake Mendota, at Madison, Wis., especially abundant in the fall.

[2] Magnus: *l. c.*

am informed that though some water-bloom occurred, and at times became offensive, especially in the latter summer, it was less abundant than in 1882. In 1885 but little was seen. Once or twice toward the end of July the scum accumulated in small quantity, but was quickly dispersed by a change in the wind, and it was not until nearly the middle of August that I was able to collect specimens. On the 10th of August quite a quantity was noticed floating in sheltered places along the University shore, and in the lee of Picnic Point, and more was seen off the shore toward Merrill's Springs, where it had stained the rocks somewhat. This consisted entirely of the *Anabæna* represented in figure 4, in good fruit.

After a warm spring, on my return to Madison, June 6, 1887, I observed a considerable quantity of putrid scum on the shore of Fourth Lake, but a south wind scattered it before specimens were obtained. The succeeding fortnight was hot, and after a couple of calm days, succeeding a strong wind from the northwest, the southern half of the lake was filled with suspended particles about a millimeter in diameter. These consisted exclusively of *Anabæna hassallii*, already in full fruit, the spores with the customary *Sphaerozyga* arrangement, in a collection made June 20th. Subsequently to this date very little water-bloom was seen, and during the entire summer the lake remained unusually free from it until September 7, when I left the city.

The water-bloom of 1886 was also slight. Floating specimens collected in the latter half of August consisted of fruiting plants of the larger *Anabaena*, similar to figure 4, with a small quantity of *Lyngbya nollei*.

The naming of this larger *Anaboena* has been attended with some difficulty. The first specimens collected, which were sterile, were referred to a form of *A. flos-aquae;* but the subsequent collection of material in fruit has shown that this reference was incorrect, if *A. flos-aquae* is understood to be characterized by globose or sub-globose spores,[1] remote from the heterocysts, and hence referable to the sub-genus *Trichormus*. It is, however, identical with the *Nostoc flos-aquae* of Lyngbya of Dr. Bornet's sketch (fig. 1), which would be referred to the sub-genus *Sphærozyga*, and agrees essentially with the type of *A. hassallii*. I should, therefore, refer our plant to *A. hassallii*. According to Wittrock, this species varies in the relative position of spores and heterocysts as widely as the three figures furnished by Dr. Bornet. Among our Madison specimens, none have been found with the spores remote from the heterocysts, but the spores are not infrequently solitary, as noted by Rabenhorst.[2]

About the middle of August 1886, while rowing across Second Lake (Waubesa), south of Madison, my attention was attracted by very numerous yellowish-green spherules about 1 mm. in diameter, floating at all depths in the water. These proved to be small fronds of *Glocotrichia*

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[1] Cf. for example, Cooke: Fresh-Water Algæ, p. 235, pl. 93, f. 1.

[2] Rabenhorst: Flora Europæa alg. aq. dulc. et submar. II., 195.

pisum. Each consists of a mass of tapering threads arranged radially in a gelatinous matrix, from the surface of which their apices protrude more or less, often rendering the surface bristling. The base of each filament is occupied by a heterocyst, followed by a slender cylindrical spore, above which come a series of vegetative cells gradually decreasing in diameter, until they form a slender colorless point.

This species has been reported from time to time in Europe, under a number of names, and has recently been discussed at some length by Bornet and Flatanet. According to Arthur, who studied a sterile form occurring in certain Minnesota lakes, it is believed to be poisonous to cattle that drink the water containing it. Usually it is found without spores, but, as I learn from M. Bornet, it can readily be kept in the aquarium for several months, during which time the sterile forms usually produce spores.

GLOEOTRICHIA PISUM Thur.—Fertile thread, (× 580.)

Frequenters of the seashore are familiar with a slime of a bright peach-color that is abundant in midsummer in and about stagnant pools in salt marshes. This is of the same nature as the scums already referred to, and is caused by what is generally called *Clathrocystis roseo-persicina*, a plant related to the chroococcaceae, but destitute of chlorophyll, and recently transferred to the bacteria, and placed under the genus *Beggiatoa*, by Zopf. Species of *Trichodesmium*, *Spirulina*, *Lyngbya*, *Oscillaria*[1] etc., which usually grow at first on the bottom, frequently break free and float in a gelatinous film of a yellowish, blue-green, violet or reddish color; and diffiused threads of some of the species of these genera more rarely form a true water-bloom[2] *Limnochlide flos aquæ* is also a common Nostochineous species that forms a water-bloom. In Europe, water is occasionally fouled, if not discolored, by *Leptomitus lacteus*, one of the Saprœgnicæ, and *Crenothrix Kühniana*, one of the bacteria closely related to *Beggiatoa*. *Beggiatoa alba* is also abundant in sulphur springs, hot ditches and stagnant bays, but is usually attached to the bottom, floating only exceptionally.

Certain species of *Peridinium* and *Euglena*, which have been regarded as infusoria until recently, but are now classed by Klebs with the algæ, are quite frequent on the water and mud of stagnant ditches, etc., in spring, imparting to it a bright red or green color. A species of the

[1] The largest of these, *Oscillaria princeps* Vauch, with filaments 50-57 μ in diameter, is found floating in such masses every season in a brook near the city.

[2] I have in my herbarium a specimen of *Oscillaria* (or *Beggiatoa*), *diffusa* Farlow, the oscillating threads of which, composed of cells 4-5 μ in diameter and 2-4 μ long, gave a pronounced purple color to the water of Jamaica Pond, Mass., in the spring of 1884, as I am informed by Dr. Farlow.

former genus was so abundant in the drinking water of Baltimore as to attract attention in midwinter, a few years since.[1]

In closing, a word may be added concerning certain objects to some extent resembling green tomatoes, that have been noticed a number of times on the bottom of the shallower parts of Third Lake, and of the larger pools along the railroads. These are of rounded form, more or less lobed, and of a pale bluish-green color. Their texture is rather firm, so that they retain their form when taken from the water, though they may be easily crushed to a formless mass of jelly, and when exposed to the air for a few days dry down into a thin film.

These bodies are colonies of *Nostoc verrucosum* Vauch., one of the Nostochineæ, which is also found in the old world. Under the microscope they are seen to consist of numerous contorted threads of a blueish-green color, imbedded in a colorless jelly that holds them together and gives form to the frond.

The following list of papers referring to the water-bloom is confessedly incomplete, but it will serve as a nucleus for other references. Only the principal papers treating of the recurrence of bacteria in quantity have been included; other references may be obtained from them. It should be added that comparatively few of the papers referred to have much botanical value.

On the flora of ice and snow fields, in Alpine and Arctic regions, which often produces striking color effects, see Wittrock, in Nordenskiold's Studien und Forschungen, veranl. d. meine Reisi im hohen Norden, Leipsic, 1885, where a bibliography of the subject is given.

The diatomaceous origin of the discoloration of Arctic seas is discussed by Robert Brown, in the Transactions of the Botanical Society of Edinburgh, IX, 1867–8.

Archer: An Oscillaria of Australian seas occurring in large quantities. (Quart. Journ. Mic. Sci., XVII, 214; Bot. Johresb., VI, I, 403).

Arthur: A supposed poisonous seaweed in the lakes of Minnesota. Proc. Am. Ass. Adv. Sc., 1883, XXXII, p. 305—abstract.

Arthur: Some Algæ of Minnesota supposed to be poisonous. (Bull. Minn. Acad. Nat. Sci., XI, 3; Fourth Rep. Univ. Minnesota, suppl. i, Rept. Dept. Agr., 1887, 97.

Arthur: Second Report on some Algæ of Minnesota supposed to be poisonous. Fourth Report Univ. of Minn., suppl. i, 109.

Berkeley: Gleanings of British Algæ. (Supplement to Sowerby's English Botany, 1883).

Bornet & Flahanet: Sur la determination des rivulaires qui forment des fleurs d'eau. (Bull Soc. Bot. de France, 1884, 76.)

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[1] As this is going to press, I notice a record of the occurrence of certain zoospores in such quantity as to cause a water-bloom (De Toni, Shrovo Gion. Bot. Italiano, xx. 295), in which references are given to several other Italian papers on this subject.

Braun: Ueber Chytridium, eine Gattung einzelliger Schmarotzergewachse auf Algennnd Infusorien (p. 50). Abhandl. Berlin, Akad., 1885, 21).

Cohn: Ueber zwei Folle von sogenanlüter wasserbüthe durch Algen veranlasst. (Sitzber. bot. sect. Schles. Ges für Vat. Culture, Nov. 15, 1877; Hedingia, 1877, 188; Bot. Jahresb., v, 31).

Cohn: Rivulanria flintaus ad int. (Hednigia, 1878, **1**; Bot. Jahresb., vi., **1**, 402).

Cohn: Untersuchungen über Bacterien. Verwandschaft von Ascococcus mit Chroococcaceen. (Beite. zur Biol der Pflanzen, I., **3**, 155 *et seq.*).

Cooke: (British Freshwater Algae, 235, 237, 240, 249, 278).

Cooke: Breaking of the meres. (Grevillea, X., 111; Am. Monthly Micro. Journal, III., 94; Bot. Jahresbericht, X., **1**, 330).

Coppinger: Oceanic phenomena. (Nature, XXIII., 482; Bot. Jahresber. IX, **1**, 370).

Dichie: Botanist's Guide to Aberdeen, 1880, 310.

Dolley: On a cilio-flagellate infusorian recently observed in Baltimore drinking water. (Johns Hopkins Univy. circulars, III., 60).

Drummond: On a new Oscillatoria, the coloring substance of Glaslough Lake, Ireland. (Ann. Nat. Hist., I., 1).

Ehrenberg: Antheil mikroskop. Organismen am Verschlämmen der Seehafen in Wisman und Pillau sowie am Schlich des Flussbettes der Elbe, und über die Miteverbung ähnlichen Erscheinung an der Bildung des Nilbodens. (Monatsber. Berlin, Akad., 1841, 127; 201).

Farlow: On certain algæ in Hom Pond. (Proc. Boston Soc. Nat. Hist., XIX., 47; Bot. Jahresber. VII., **1**, 460).

Farlow: Remarks on some algæ found in the water supplies of the city of Boston. Bull. Bussey Inst., Jan., 1877).

Farlow: Paper on some impurities of drinking water. (Rept. Mass. Board of Health, etc., I., 131.)

Farlow: Notes on fresh water algæ. Bot. Gay., VIII., 224, 246.

Farlow: Relation of certain forms of algæ to disagreeable tastes and odors. Proc. Am. Ass. Adv. Sc., XXXII., 1883, 306.—Abstract.

Farlow: On the nature of the peculiar reddening of salted codfish during the summer season. (Rept. U. S. Fish Commission, 1878, 969). See also Revue Mycologique, VI., 197, VII, 17).

Farlow: Vegetable parasites of codfish. (Bull. U. S. Fish Comm., VI., 1, 1886).

Fleischer: Uber ein massenhaftes Aufstreten von Protococcus roseopersicinus Ktz. (Hedingia, II., 37.

Francis: Poisonous Australian lake. (Nature, XVIII, 11; Bot. Jahresb., VI., **1**, 402).

Giard: Etude sur une bactérie chromogéne des laux de rouessage du lin. Rev. Sci. Nat., V. *Fide* Zopf.

Girod Chantrans: Recherches chemiques et microscopiques sur les conferves, etc. (Paris, Ann., x.—Vide Schultz, 495).

Gobi: Mittheilungen über Rivularia flos aquae Gobi. (Arbeiten Ges. Naturf., St. Pétersb., X.; Bot. Zeitung, 1880, 478).

Gobi: Ueber eine die Erscheinung der Wasserblüthe im Meerwasser hervorrufende Rivularia. (Hedingia, 1878, 33.—Nachtrag. *l. c.*, 49; Bot. Jahresber., VI., **1**, 402).

Harz: Ueber die im veriflossenen Jahre beobachtete Trübung des Schlierseewassers. Bot. Centralblatt, 1887, XXX, 286, 331.

[Hitchcock]: Water colored by Algae. (Amer. Monthly Micr. Journal, III., 94).

Humboldt: Bericht uber die natur hist. Reisen der Herrn Ehrenberg und Heimpridt.—*vide* Schultz, 495.

Magnus: Das Auftreten von Aphanizomenon flos aquae (L.) Ralfs in Eise bei Berlin. (Ber. deutschen Bot. Gesellsch., I., **3**, 129; Bot. Jahresb. 6, XI., **1**, 293).

Montague: Mémoire sur le phénomène de la coloration des eaux de la Mer. Rouge. (Comptes rendus, July 15, 1844; Ann. Sci. Nat., Ser. **3**, II., 332).

Montague: Note sur un nouveau fait de coloration des eaux de la mer par une algue microscopique. (Comptes rendus, Dec. 16, 1846; Ann. Sci. Nat., Ser. **3**, VI., 262).

Montague: Résumé succinct des observations faites jusqui ici sur la rubéfaction des eaux. (Mém. Soc. de Biologie, I., 59).

Olivier: Recherches sur la rubéfaction naturelle de l'eau. (Bull. Soc. bot. de France, 1881, 216).

Pavesi: Faune pélagique des lacs de Teasin et d'Italie. (Archives des Sci. phys, et nat., Geneva. Ser. 3, IV., 151; Bot. Jahresb., VIII., **1**, 538).

Phillips: Breaking of the meres. (Grevillea, IX., 41).

Phillips: The breaking of the Shropshire meres. (Trans. Shropshire Archaeol. and Nat. Hist. Soc. [1884?], 1).

Ralfs: On the Nostochineae. (Ann. and Mag. of Nat. Hist., Ser. 2, V., 321).

Ray Lankester: On a peach-colored Bacterium. (Quart. Journ. Micr. Sci., *n. s.*, XIII., 408).

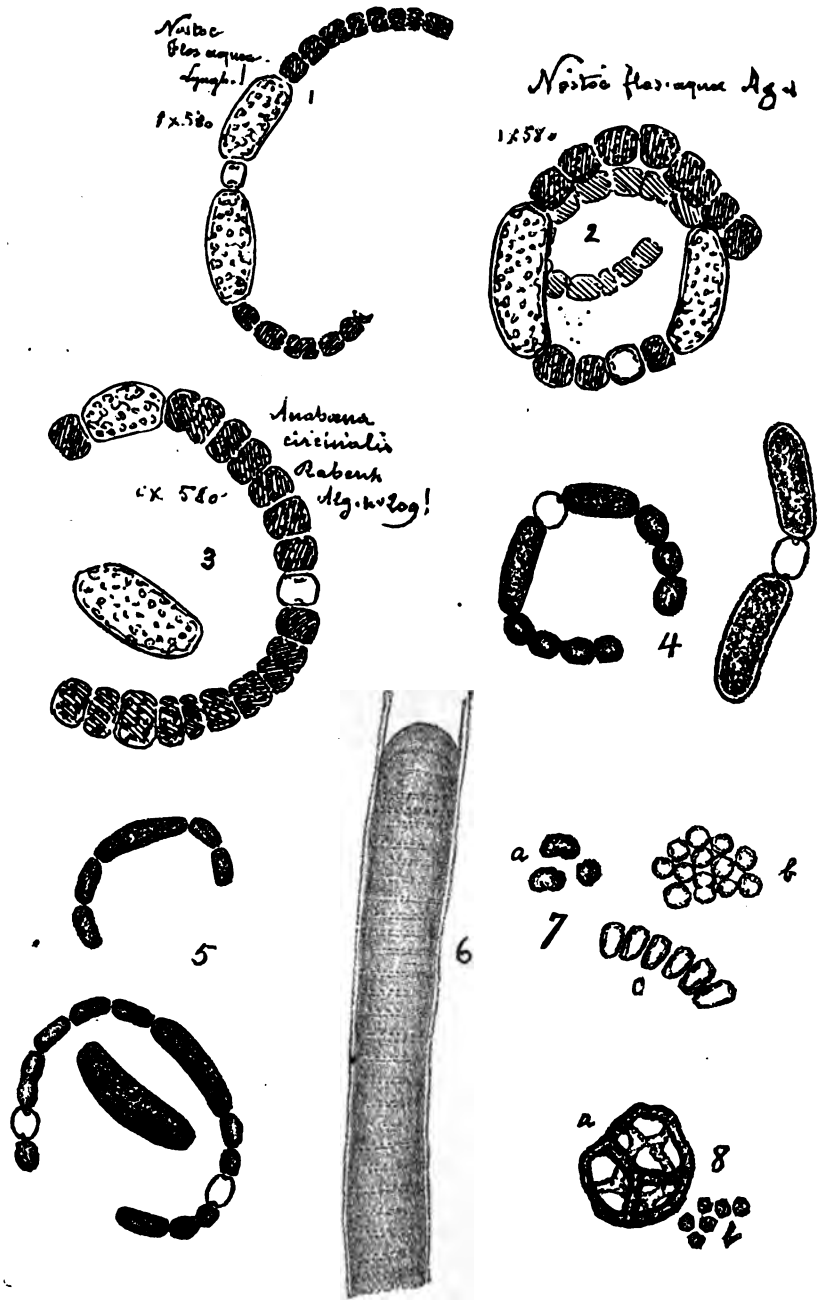
Ray Lankester: Further observations on a peach or red-colored Bacterium. (Quart. Jour. Micr. Sci. *n. s.*, XVI.).

Richter: Ueber die in den Enterichelungskries von Beggiatoa roseopersicino geborenden seitheirgen Algenspecies. (Hedingia, 1884, 177).

Richter: Microcystis Kütz., ein einzuziehendes Algengenus. (Hedingia, 1885, 18).

Schneider: Mittheilung über die grünen und gelben Streifen in dem Meer von Java. (Naturk. Tydskr f. ned. Indie, 1873, XXXIII., 302; Lotos, 1875, 63; Bot. Jahresber., III, 41).

Schnetzler: Ueber eine rothe Tärbung des Bretsees (lac de Bret), Bot. Centralblatt, 1887, XXXI., 219.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Schultz, C. H.: Die Fortpflanzung und Ernährung du Pflanzen, 1828, 495.

Stalher. Report on the Waterville cattle disease (see Arthur). Fourth Rep. Univ. Minnesota, Suppl. 1, Rep. Dep. Agr. St. Paul, 1887, p. 105.

Thompson: An Alga which colors Ballydrain Lake (Ann. Nat. Hist., 1840, 75).

Treichel: Ueber Polycystis aernginosa Kütz, als Ursache von roth gefärbtem Trinkvasser, (Ber. 2 Versamml. Westpreuss. Bot. Zool. Vereins zu Marienweider, am 22 Juni 1879.—*fide* Bor. Jahresber., VII., 1, 486).

Weisse: Monas Oheini. (Bull. Phys. Math. Acad. St. Petersburg, III., 310).

Weisse: Zereite Verzeichniss St. Petersb. Infusorien. (Bull. Phys. Math. Acad. St. Petersburg, III., 333).

Wittrock: Anabaena (Dolichospermum) Nassallii (Kütz.) Wittr. (Wittroch & Nordstedt's Algae aqæ dulcis exsiccatæ, No. 496; Bot. Notiser, 1882, 58; Bot. Jahresb. X. 1, 330; XI. 1, 244, 280.)

Wolle: Fresh Water Algæ. Bull. Torr. Bot. Club, VIII.,38; and Fresh Water Algæ of the United States, Bethlehem, 1887.—various places.

Wood: Contribution to the history of the fresh water algæ of North America, p. 39, etc. (Smithsonian Contributions, 1872).

Zopf: Die Spaltpilze, 1883, 74 *et. seq.*, where other references concerning Beggiatoa, etc., are given.

Description of Plate X.

1—4. *Anabaena hassallii* (Kg.) Wittr.

1. Filament of *Nostoc flos aquae* Lyngb. (× 580). From a sketch kindly furnished by Dr. Bornet.

2. Filament of *Nostoc flos aquae* Ag. (× 580). From sketch by Dr. Bornet.

3. Filament and spore of *Anabaena circinalis* Rab. (× 580). From tracing by Dr. Bornet, from analyses of Algen Sachsens, No. 209.

4. Fertile filament and two mature spores of *Anabaena* (*sphaerozyga*) *flos aquae* (Lyngb.) (× 580). From Lake Mendota.

5. Two filaments and mature spore of *Anabaena mendotae* Trelease. (× 580). From Lake Mendota.

6. Part of filament of *Lyngbya wollei* Farlow. (× 580). From Lake Mendota.

7. *Coelosphaerium Kützingianum* Noeg. From Lake Mendota.—*a.* Fronds (× 25). *b.* Group of cells as seen from the surface (× 580). *c.* Cells as seen in radial section of frond (× 580).

8. *Clathrocystis aeruginosa* (Küttz). From Lake Mendota.—*a.* Frond (× 25). *b.* Single cells (× 580).

THE VILLAGE COMMUNITY AND SERFDOM IN ENGLAND.

BY PROF. WM. F. ALLEN.

The existence of village communities with collective ownership of land, in England, is a fact of comparatively recent discovery. Long after von Maurer and the writers of his school had submitted the subject to an exhaustive investigation, in relation to the Teutonic countries of the continent, it was believed that England afforded no examples of the system. The eye of the American traveler upon the continent is constantly struck by the ribbon-like strips which almost everywhere testify to a system of occupation and cultivation of land differing widely from that of his own country; while in England the fields, of irregular size and shape — although enclosed with hedges instead of stone walls and rail fences — are precisely what he is familiar with at home. It was only after the inquiry was, so to speak, completed for the continent, that a German scholar, Prof. E. Nasse, of Bonn, took it up in relation to England, and showed that here, too, the system of village communities, with an open-field system of husbandry, was the prevailing one during the middle ages.[1]

The line of inquiry entered upon by Prof. Nasse in the work referred to, was shortly after followed out by Sir Henry Maine in his "Village Communities," (1871); and more recently Mr. Frederick Seebohm, in his "English Village Communities," (1883), has given a description and analysis of this institution which could not be surpassed in thoroughness and lucidity. Since the publication of this work, in 1883, there has no longer been any room for difference of opinion as to the existence of village communities in England, or indeed as to their organization in almost the smallest detail. A new controversy has, however, been suggested by his work. Mr. Seebohm holds that these village communities were not, in their origin, groups of free peasant proprietors, reduced by gradual steps to a condition of serfdom, as the accepted theory maintains, but that serfdom was their original condition, there having been no essential change in this respect from the first settlement of England down through the feudal period. This view is closely connected with Mr. Seebohm's theory of the primitive aristocracy of

[1] See his treatise, translated and published by the Cobden Club: The Agricultural Community of the Middle Ages, and Inclosures of the Sixteenth Century in England. London: Williams & Norgate, 1872.

the Germanic nations, which I discussed in a former paper.[1] Holding that serfdom was the original condition of the mass of the German people, he naturally holds that the same was true of the English settlers. And it must be conceded that, if his theory is true for Germany, it must perforce be true for England, while the converse does not hold. To prove the primitive democracy of the Germans does not prove a primitive democracy for the English, for the reason that their migration and conquest of a foreign land may have worked a fundamental change in their social institutions.

The question to be considered is, it will be seen, not whether the village community existed or not; that has been placed beyond controversy by Messrs. Nasse and Seebohm. It is, whether it was a free or a serf community; and the question resolves itself at once into a larger one, as to the origin of serfdom in England. This will form the subject of the present paper.

It has generally been held that serfdom in England was in part at least the result of a gradual deterioration in the condition of an originally free peasantry — that while no doubt some serfs were in their origin emancipated slaves, and others conquered Britons, while others again were brought over as serfs by the English conquerors; nevertheless the largest portion of them were the descendants of the conquerors themselves, the rank and file of the invading armies, who had sunk by degrees to a condition not much above that of the native Britons. This view is disputed by Mr. Seebohm. According to him there was no large body of free Germans, but the invading armies were composed of chieftains with servile followers, whom they settled at once as serfs upon their estates. The manorial system of the middle ages, therefore, existed from the first; the free Angle or Saxon was the lord of the manor, or thegn, the serfs whom he brought with him, or found already upon the soil, were the same body as the villeins of the feudal period.

His line of argument is as follows: Finding serfdom to be the condition of the peasantry in the middle ages in association with the village community, he traces both institutions back by an inductive process of remarkable ingenuity and cogency, to the reign of Alfred, at the beginning of the tenth century, at which point of time he shows that the condition of the peasantry did not differ essentially from what it was in the reign of Edward I., four hundred years later. Further back than this he is not able to go with the same thoroughness of detail, for the want of documentary evidence; he finds, however, passages in the laws of the seventh century which appear to support his view, and maintains that if we find no change in tracing the institution back six hundred years to the time of these laws, we should not be likely to find any change if we could trace it back still further for the much shorter period of two hundred years or so, to the first settlement of the Angles and Saxons in Britain. This argument is still further strengthened by the assertion that serfdom not merely existed in the

[1] See Transactions of the Wisconsin Academy, Vol. VI.

tenth century (and probably in the eighth) as well as in the thirteenth but that it was more complete and harsh at the earlier date than at the latter. If these conclusions are correct, if the agricultural population of England was in a condition of serfdom uninterruptedly from the eighth century to the thirteenth, and if its early form was more severe that its later, he must be admitted to have made out his case.

As to the first point, it should be noted that he has *proved* the existence of serfdom only as far back as the tenth century; its existence at an earlier date is only an inference, partly from analogy, partly from evidence which, as will be shown further on, proves the existence of the open-field system of husbandry, but not of serfdom. The positive evidence goes no further back than the time of Alfred. Now the interval between Alfred and the original settlement of the Anglo-Saxons in Britain is just about as long (400 years) as that between Alfred and Edward I.; moreover, it is an important consideration that the years directly following the conquest would be likely to witness far more rapid and radical changes than the ater period.

The second point in his argument, that serfdom is found to be more harsh in its type as we trace it further back in time, requires a careful examination, being opposed to the accepted view, and resting upon evidence of a rather doubtful character. We have numerous documents belonging to various point of time from the tenth to the thirteenth century, which contain a detailed enumeration of the duties and obligations of serfs, as well as the amount of land they held. Now the obligations, so far as they are specifically enumerated, are much more numerous and burdensome at the later period than at the earlier: but, at the earlier date, we find, in addition to the specific obligations, such general and indefinite ones as: "to work as the work requires," and "every week do what work they are bid." In such general and unlimited obligations as these, he says, consists the essence of servitude.

This argument requires that the obligations, beginning in the tenth century with unlimited liability to labor, should go on regularly lessening in amount and becoming easier through the feudal period. The contrary is, however, the case. Leaving out of account for the present the indefinite expressions just cited, to which we shall return presently, we find the precisely enumerated obligations to be less in the tenth century than in the twelfth, and in the twelfth century again to be less than in the thirteenth. That is, while there is an uninterrupted continuity through these four hundred years in the organization of the peasantry and the general character of their obligations, these obligations, as specified in detail, appear to have been steadily increasing during this period. Even the example given by Mr. Seebohm (p. 157), of the manor of Tidenham at the two periods, sustains this view, except for the phrase, "work as the work requires," at the earlier period; and a comparison of the duties specified in the *Rectitudines singularum personarum* with the numerous descriptions in the *Rotuli*

hundredorum or the Cartularies in the reign of Edward I., shows a much larger amount of required labor at the later period.[1]

In one instance we have positive evidence in detail of this increase in burdens. The residents of Weston, in Bedfordshire, made a complaint to the officers of Edward I. that, in the reign of his grandfather, King John, they were accustomed to labor in autumn only for three harvest days, on which days they were provided with food at their lord's table, one day of fish and two of meat. But William de Bokland, to whom King John granted the estate, increased the aforesaid service by one additional day, at the lord's table. Afterwards the aforesaid manor came to John Tregoz, who augmented the service to such a degree that now they perform ten days' work in autumn at their own providing, and one day besides.[2] Here we have on record an actual example of an abuse of power by the feudal lord, in increasing the burdens of his serfs, such as we must suppose to have been common in those evil days. It is a significant point that the extortions here described were not the work of one man, but of three successive proprietors.

As to the phrase in question — to do "every week what work they are bid" — it is best explained as a general authority to call upon them when there was need, with an understanding that no unreasonable demands should be imposed upon them. In this respect this obligation resembles the feudal aids and tallages, which also were levied at discretion, but were understood to be only occasional, and implied nothing servile in the relation. Feudal aids and tallages were nevertheless liable to abuses and extortion by reason of their indefiniteness, and were at last defined by law. So in like manner the indefinite obligations in question gave opportunity for arbitrary exactions, like those in the manor of Weston, described above. It may have been the case, too, that such obligations as these were not universal, but peculiar to such and such an estate. The tenth century document, *Rectitudines singularum personarum*, says distinctly that the obligations vary, being lighter here and heavier there; but what it describes as the usual ones are much less in amount than what was common in the

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[1] Compare, for the earlier period, the *Rectitudines singularum personarum*, the Codex Diplomaticus, No. 977, and the illustration given by Mr. Seebohm, p. 157: for the twelfth century, the Domesday of St. Paul, and the Abingdon Cartulary, Vol. II, p. 301; for the close of the thirteenth century the documents are very abundant, the most numerous examples being in the *Rotuli Hundredorum* and the Gloucester Cartulary, Vol. III.

[2] In tempore Regum Henrici et Johannis dicti homines non consueverunt operari in autumpno nisi tantum tres messes in quibus diebus debebant exhiberi in cibis et potibus ad mensam domini una die in esu piscium et aliis duabus in esu carnium. Postmodum Willelmus de Boclond augmentavit dictum servicium et per ipsum crevit per unam diem messis ad mensam domini. Postmodum Hamo le Crevequer tenuit dictum manerium in eodem statu toto tempore . . . Item deinde venit dictum manerium ad manus Johannis Tregoz qui praedictum servicium augmentavit in tantum quod modo fiunt decem operaciones in autumpno ad mensam suam. Item praeter istam operacionem exigitur ab hominibus praedictis una water-bederipe et fit. Et tunc bibunt aquam, et hoc crevit primo per dictum Hamon, etc. *Rotuli Hundredorum*, i. 6.

thirteenth century. It should be noted also that the *Rectitudines* speaks distinctly of the tenants in question as freemen.[1]

I cannot, therefore, concede to this part of Mr. Seebohm's argument the weight which he claims for it. He does not seem to me to have proved that the obligations were less in the thirteenth century than in the tenth; on the other hand the evidence seems to me to lean strongly the other way. But he has proved, and it is a fact of great importance, that the character of the obligations, and the status of the peasantry, did not, so far as our information goes, differ essentially in the tenth century from what we find in the thirteenth. It is, therefore, perfectly legitimate on his part to infer that this condition of the peasantry, found alike in the thirteenth and in the tenth century, probably existed in the earlier centuries also. The inference is, however, only a probable one, in the absence of direct evidence, and direct evidence is wanting. For the period before the time of Alfred, he is obliged to have recourse to indirect evidence, in the assumption that serfdom and the "open-field husbandry" went together.

Up to this point he has traced the open-field system and serfdom step by step, accompanying each other hand in hand. Beyond this point he is not able to trace serfdom, but the open-field system is traced back at least two centuries further, and he says that, as it has always carried serfdom with it in the later period, it may fairly be assumed to do the same thing in the earlier period. "The community in villenage," he says (p. 105) "fitted into the open field system as a snail fits into a shell." But it is by no means clear that a free community might not have fitted into this shell equally well, as, indeed, the prevailing theory holds. The only argument to prove that the community could not have been a free one is (p. 177) that the Teutonic custom of dividing estates equally among heirs would have led to endless and intricate subdivisions of land. But this is exactly what we find to have been the case. The virgate or "yard-land," which he assumes to have been the regular peasant's holding, and which as a matter of fact was the usual one in the thirteenth century, was the fourth part of a hide; and it is generally held that the hide, not the virgate, was the original holding. And at any rate, in the thirteenth century, we find tenures of half and quarter virgates, and even smaller aliquot parts, by the side of the regular tenure of the virgate;[2] exactly the condition of things which Mr. Seebohm says would have come about.

To carry back, therefore, the open-field system to the seventh and sixth

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[1] *Sicut omnis liber facere debet.*

[2] For example, in the manor of Broctrope (Gloucester Cartulary, iii, p. 140), I find among the freeholders two tenants holding entire virgates, and five holding half virgates; and among the customary tenants one with a virgate, nine with half-virgates, two with quarter virgates, and five with an amount of land equal to a sixteenth of a virgate, these differences evidently coming from the sub-division of the original hide. For other examples, see my paper on Rural Classes in the Thirteenth Century, Vol. II, of the Transactions of the Academy: that the socage freeholds were originally servile holdings is shown in my paper on the Origin of the Freeholders, Vol. IV, of the Transactions.

centuries, as Mr. Seebohm does by almost certain inference, is a valuable contribution to our knowledge; but that serfdom went back with it is an unwarranted inference. The question of freedom or serfdom is the fundamental one, that of land tenure or husbandry being really but secondary. To this fundamental question of status, therefore, we will now apply ourselves, leaving that of land occupation aside for the present.

At this point it must be conceded, as I have said before, that the existence of a large body of free peasants in the Germanic nations of the continent, which I consider to be fully proved, does not necessarily prove the existence of the same class in England. The Angles and Saxons settled forcibly and very slowly in Britain, and it is not in itself impossible that the whole body of the Conquerors became a landed aristocracy in their new home, establishing such a system of manors, with a population of serfs upon them, as we find in later centuries. This is Mr. Seebohm's view. But the probability is the other way. The Angles and Saxons did not enter Britain as the Normans did afterwards, as a handful of conquerors, ruling over a subject people. They came *as a people*, bringing their wives and children with them, not *as an army*; and with regard to the Angles we are expressly told[1] that they left vacant the country which they had formerly occupied — the entire people having migrated. Moreover the native inhabitants were *as a people* exterminated; in the eastern parts of the island their language, their religion, and so, far as we can judge, their institutions and customs disappeared. If the invaders established a system of serfdom in Britain, they must have brought the serfs with them, otherwise the servile population would have had the preponderence of numbers, and the resulting community would have been, as in the case of the Normans and the Franks, the native population with an admixture of the conquerors, instead of — as the language shows to have been the case — the conquering population with an admixture of natives. Now the Germans had in their native land a class of serfs called *lidi* or *lazzi*, and the Anglo-Saxon laws mention a similar class called *laet*, whom we must suppose to have been the serfs (*lidi*), brought with them by the invaders. These *laet*, the serfs of the Anglo-Saxon period, Mr. Seebohm suggests (p. 175), may have been identical with the *villani*, who were the serfs of the later middle ages. This cannot, however, be the case, as the *villani* are invariably identified with a quite different class, the *ceorls*.

This brings us to the most fundamental question in the subject under consideration: Were the *ceorls* of the early period a free or a servile class? Two things are entirely certain: first, that the Anglo-Saxon *ceorls* were the *villani* of the Latin documents; secondly that the *villani* of the later middle ages were serfs. The point at issue is whether these *ceorls* were originally serfs, as Mr. Seebohm's theory would require, or became serfs by a gradual process of deterioration, as the common theory holds. I shall en-

[1] *de illa patria quae Angulus dicitur, et ab eo tempore usque hodie desertus inter provincias Jutorum et Saxonum erhibetur. Beda. Hist. Eccl., i*, 15.

deavor to show: first, that the *ceorls* of the early Anglo-Saxon period were freemen; secondly, that the *villani* of the later period were not always serfs, there being found some survivals of their original free condition.

The first thing to be noted is that, as has been already pointed out, there was, in the early Anglo-Saxon period, a class known by the name of *laet*, who were undoubtedly serfs, the *lidi* of the continent. They had below them the slaves, *esne* and *theow*, and above them the *ceorls*. Now as the *ceorls* certainly ranked above this servile class, it may be assumed that they were themselves probably free. This probability is made stronger by the consideration that the Saxons of the continent had a class of common freemen intermediate between the *lidi* or serfs and the *edelingi* or nobles, a class which has no representatives among the Anglo-Saxons unless in the *ceorls*, the class under consideration. This class upon the continent was called *frilingi*, and in Anglo-Saxon also we meet the *friman* (freeman)[1] although this term is for the most part superseded in the early Jutish laws by the Scandinavian word *ceorls*.

The probability is therefore that the *ceorls* were a free class. We will proceed, however, to examine the actual uses of the word, in order to determine whether this probability is sustained by facts. First we will take up the poems of Beowolf, a work which, whatever its date and place of composition. unquestionably presents the most ancient picture in existence of the institutions, condition and manners and customs of the Anglo-Saxons. In this poem I find the word *ceorl* six times. In none of these is it applied to a servile class, or even used in a disparaging sense. Twice (vv. 416 and 2,972) it is used of princes; in three cases (vv. 202, 908, 1,591) of the people in general, and in the sixth case (v. 2,444) of a man of the people. If it has one meaning that could apply to all these cases, it is perhaps *man*.[2]

We pass next to the Anglo-Saxon codes of law. In the earliest of these laws, those of Ethelbert of Kent (about 600) *ceorl* is several times used as equivalent to *man* or even *husband*. It is also used to designate a legal class below the King and *eorl* (officer). The King's *mundbyrd* is placed at 50 shillings, the eorl's at twelve, the ceorl's at six. The ceorl was therefore a man of standing. He even had other men under his protection. Section 16 speaks of his cup-bearer, *birele*, section 25 of his *hlaf-aeta* "loaf-eater" or dependent—the correlative of *hlaford* (lord) or "loaf-giver." The ceorl could therefore be the lord of another man. Section 17, following directly upon the mention of the ceorls' *mundbyrd* and *birele*, speaks of a *man's tun* or estate, as it has before spoken of the King's and the corl's *tun*;

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[1] Leg. Aeth. 24, 27, 29, 31.

[2] It should be noticed that in the *Rigs-mal*, the allegorical poem which treats of the origin of the Scandinavian classes, *Karl* (*Ceorl*) is the common freeman, "the red-haired and ruddy cheeked lad with piercing eyes," whose sons were "Freeman and Braveman, Hold, Thane and Smith, Broadshoulders and Bonde [*Peasant*]" etc. The corresponding German word *Kerl* has a somewhat disparaging signification, while the English word *churl* is significant of the degradation which the class sustained in England.

evidently the *man* here is the *ceorl;* the ceorl could therefore have an estate of land.

The later laws of Kent contain nothing that adds to the evidence here given. The next stage in the inquiry is the laws of Ine of Wessex, about 700, that is, about 100 years after those of Ethelbert, and 200 years after the first settlement of Wessex. In these laws we find clear recognition of the ceorls as a free class, inferior to the noble class of *sithcundmen.* The ceorl's fine for neglecting military duty is 30 shillings, that of the *sithcundman* being 60 or 120, according as he had land or not (§ 51). Now by Germanic law none but freemen could render military service. Therefore the ceorl was a freeman. Again, in accusations of homicide, he is placed in regard to compurgation on precisely the same footing with the *sithcundman* (§ 54). On the other hand a certain degradation is clearly visible, in the penalty of amputation of hand or foot, inflicted for certain offences (§§ 18, 37). It would appear also that the ceorl was already required, or at least expected, as he certainly was afterwards required, to have a lord; sections 37, 38 and 40 treat of the ceorl, and between them comes § 39, referring to "any one" running away from his lord — which would certainly seem to mean "any ceorl."

There is another passage of the laws of Ine (§ 67), brought up by Mr. Seebohm, as a proof of the existence of serfdom at this period, but which rather shows that it was in the process of introduction, than that it was already existent. I give his translation. "If a man agrees for a yard-land or more at a fixed gafol (rent) and plough it, if the lord desire to raise the land to him *to work and to gafol* he need not take it upon him if the lord do not give him a dwelling." This statute testifies to the practice of exaction and encroachment by which tenants were converted into serfs, a process well attested at this very period in the Frank monarchy. It is clear that the peasants (assuming them to have been originally free), had already in large part been reduced from proprietors to tenants, the lands were rapidly being absorbed into large manorial estates, and by the same process their proprietors were becoming tenants; the next step was to convert them from free tenants into serfs.

At about this period — the close of the seventh century — belong the earliest (except three or four) of the charters and land grants, which exist in great abundance, and afford the most valuable material for the study of early English social and economical relations. In them we find that the grants consist regularly of estates with their tenants;[1] and the size of the

[1] The charters in question begin in the reign of Ethelbert of Kent, the first Christian king, in the year 605. In all his charters the grants are merely of land — *aliquantulum telluris mei* (a little bit of my land) Thorpe's *Codex Diplomaticus,* No. 1; *aliquam partem terrae juris mei* (a certain part of the land under my jurisdiction), No. 2; *villam nomine Sturigao* (an estate named Sturigaw.), No. 4. A charter of his son Eadbald (No. 5) says *quandam partem terrae regni mei,* xxx *aratrorum* (a certain part of the land of my kingdom, 30 plough-lands). It is not until the close of the century, that the land is defined as of so many occupants; the first is (670) No. 7, *unum cassatum* (one cottager). From this time

estates is regularly estimated by tenants — *cassati*, *manentes*, *tributarii*, sometimes *mansa* and *hida*, all these terms being used as equivalent.[1] This shows that the peasants were at this time largely tenants upon the estates of others; it does not show that they were originally so, or that they were serfs. That they were still personally free, although upon the point of losing their freedom, is, I think, proved by the evidence which I have brought up: it is a fair inference, from the analogy of other Germanic nations, that their land was also originally their own, and this seems also to follow from the mention of the "mannes tun" (Aeth., 17), when speaking of the ceorls.

After Ine's laws, of about the year 700, there is a gap of nearly two hundred years, until the time of Alfred, in which reign the series of statutes begins again, and continues in an unbroken succession until the conquest. The most important change noted in the new series of laws after this interval, is the uniformity and reiteration with which it is required that every man must have a lord, and the rights of the lord are maintained against the caprice of the man, or the rivalry of other lords. *Omnis homo habeat advocatum suum* (every man shall have his surety) Edward, 1.: *non recipiat aliquis hominem alterius sine licentia illius* (No person shall receive the man of another without his permission), id. 7., are regulations repeated in substance in nearly every body of laws. But notwithstanding the rigid requirement of this submission to a lord, it appears that there still survived a certain freedom of choice in the act: *ne dominus libero homini hlafordsoknam interdicat* (let not the lord prohibit the free man to choose a lord). Here the free status of the man is clearly implied; and in the laws of Alfred we have a number of provisions testifying to the lawworthiness and therefore original freedom of the peasants. *Si quis in ceorlisces mannes flet gefeohte, i. e., in rusticani hominis domus area pugnet* (if any one fights in the court of a ceorl). Section 40. *Ceorli eodorbrece, i. e., rustici sepis fractio* (trespasses upon the enclosure of a ceorl), where the ceorl is placed on the same footing as the king, the bishop, the alderman, etc. Section 10 places the ceorl on the same legal footing with the twelfhynd and sexhynd men, who were thegns. Section 25 speaks of *ceorles mennen*=

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this is the universal method; but there are several expressions which show that it is still the land, reckoned in peasants' holdings, rather than the peasants themselves, that is conveyed by the grant. No. 8, (675) says *quandam terram . . . . id est, decem manentes* (a certain piece of land . . . that is to say, ten tenants). No. 10, *terram . . . xviii manentes continentem* (land containing eighteen tenants.) No. 12, *centum manentes qui adjacent civitati* (100 tenants adjoining the city). No. 33 (691) *terram . . . quadraginta quatuor cassatorum capacem* (land containing forty-four cottagers). No. 40, *quadraginta terrae illius manentes* (forty tenants of that land); and, especially, No. 20, *terra super verticem montis. . . est sub estimatione sex manentium* (land on top of the mountain reckoned to be of six tenants). In all these cases it is clear that measurements of land are in question, and in the last instance it is apparently unoccupied land, roughly estimated in terms of peasant holdings.

[1] " . . . *terram septies quinos tributariorum jugera continentem. Est autem rus praedictum in quatuor villulis separatum . . . quinque manentium . . . decem cassatorum . . . decem mansionum . . . decem manentium.* Cod. Dipl. cxi.

ceorles mancipium (the slave of a ceorl). Sections 11 and 35 are peculiarly significant, as they aim to protect the ceorl and his wife against personal violence; showing that, while they were still free in law, they were nevertheless on the road to serfdom, and were especially subject to abuse by the powerful.

We have thus followed the word *ceorl*, and the class which it designates (the peasants) from the earliest times down to the time of Alfred, exactly the point of time which Mr. Seebohm reached, from the opposite direction. As he traced the manorial organization and a servile peasantry step by step from the time of Edward I. back to that of Alfred; so we have traced a class of free peasants from the time of the original conquest down to the reign of Alfred, and have found it gradually subjected to restrictions and obligations which have converted it into a servile or semi-servile class. Mr. Seebohm's serfs were known as *villani;* the free peasants of the early period were known as *ceorls*; and there is the most indisputable evidence that these are the Latin and the Anglo-Saxon names respectively for the same class; this class was the peasantry, who, by this evidence, appear to have been at first freemen and afterwards serfs.

Undoubtedly there were manorial estates, with serfdom, in the earliest times, existing by the side of the townships of free peasants, and following the same system of open-field husbandry. On the other hand it appears clearly that the entire class of peasants or ceorls was not reduced to servitude. We could not be surprised if no free *villani* or free townships (*villæ*) were met with in the records, for it was only the proprietory townships, or manors (especially those belonging to ecclesiastical proprietors), which had a sufficiently systematic administration, and exercised sufficient care in the preservation of documents, to afford adequate evidence as to their existence and condition. But as a matter of fact there is clear evidence of free peasants and even of free townships in the feudal period. For example: Alvarstoke in Hampshire, at the time of Domesday Brook (i. 41, b.) was held by its own *villani* (*ceorls*), tenants of the convent of St. Swithin, of Winchester. The number of *villani* was forty-eight, and there were no slaves, or tenants of a lower grade (*bordarii*). Two hundred years later their charter was confirmed by the prior of Winchester, to the effect "that they and their posterity (*sequela*) should be forever free and quit from tallages, salt-rent, cherset of hens and eggs and pannage of hogs; should be at liberty to make wills and dispose of their children and avers [*averia*= *beasts*]; . . . all pleas except pleas of the crown should, by consent of both parties, be pleaded and tried without delay in the court of Alwarstoke, in the presence of the prior and his seneschal, according to the law and customs of England, and the usage of the free tenants of the county." This document is fortified by the seal of the community, given by Sir Frederic Madden in the Winchester volume of the Archæological Proceedings as: *Sigill: comune: hominum: prioris: Sci Swithuni: de Alwarestoke.* In 1841 an inquisition declares "that there are no traders in Alverstoke,

and that all live by agriculture and hand labor." Melebroc (Millbrook) in the same county the Domesday record (i. 41, b.) gives as being held by *villani.* Of Ibthorpe we are told: "The people of Ibthorpe are lords of their own manor and to this day exercise their manorial rights."[1] It is hard to explain these cases except as original village communities of free peasants, who, in losing the ownership of their land and becoming tenants, did not lose their freedom or their rights as a community.

I have shown that the Anglo-Saxon *ceorls*, or peasants, were in the sixth and seventh centuries, that is the period directly following their migration to England, not serfs but freemen, possessing houses, lands, serfs and slaves of their own; that at the end of the seventh century, the period of the laws of Ine, they are still distinctly recognized as freemen, but as subject to certain exactions and encroachments on the part of the more powerful classes, which were reducing them to a semi-servile condition, in particular encouraging the practice of *commendation*, or placing themselves under the protection of a lord, and becoming his "men;" and that in the time of Alfred this practice of commendation had become universal and obligatory, and their servile condition distinctly recognized.

In short, the history of the English peasantry in the Anglo-Saxon period, corresponds very closely to that of the same class upon the continent in the same period. In both England and Germany the free peasants appear to have been forced, by the disorders and distresses of society to *commend* themselves, or seek the protection of men higher in station than themselves, The protection was not granted without some equivalent — service, following, surrender of land to be given back again as tenure, requirements of labor, becoming more and more onerous as the relation became more and more fixed, until at last they were stripped not only of their possessions, but even of personal freedom, and reduced to the state of complete serfdom: — not so complete, however, in the case of the English peasants, but that the memory of their original freedom was preserved in the principle that it was only in relation to their lords that they were serfs, and that towards all others they were freemen, having well defined rights before the law, and a recognized place in the constitution.

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[1] Antiquary, February, 1888.

TOWN, TOWNSHIP AND TITHING.

By Prof. Wm. F. Allen.

The town is in many respects the most characteristic institution of the political system of the northern states of the American Union, and of the primitive constitution of the English people. It may be defined as a territorial district, the inhabitants of which compose a body politic, small enough to allow the immediate participation of all its citizens in the government of its local concerns, and forming an organic part of the structure of the state. Its powers of local self-government are not original and inherent, but derived from the larger body of which it forms a part; they are nevertheless substantial and permanent, in this respect differing from those of the school districts or wards into which the town or city is divided. The City under our system is only a larger and specially organized Town; the Incorporated Village of New York and the West is a peculiar addition to the Town system, not forming structurally a part of it.

The Town, as thus defined, is peculiar to England and the United States, and, in its complete development, to the New England States. In all the other Germanic countries the territorial division corresponding to the Town stopped short of an independent political life, being, from the point of view of the State, nothing but a private corporation for economical purposes, with only inchoate functions as a body politic. In all these countries the Hundred was the smallest district of a public character; just as in our southern states the County is the agent of local self-government. But the County and the Hundred are too large to allow the immediate participation of all the citizens in the transaction of public business. The communities in which these large districts are the only agent of local self-government are necessarily aristocratic in their political character. It was the growth of Feudalism, or the establishment of centralized monarchies, in the Germanic countries of the continent, that checked the development of an institution corresponding to the English Town. In England the growth of a landed aristocracy and of a centralized monarchical power were not early or rapid enough to kill the germs of local self-government, although they seriously interfered with its development.

The political functions of the English towns were so largely obscured during the middle ages by the manorial or feudal organizations to which they were subjected, that there have arisen some doubts as to their extent, and even their existence. Bishop Stubbs, in his "Constitutional History of

England" (Vol. i, p. 82), asserts that (in Anglo-Saxon times) "the unit of the constitutional machinery is the township, the *villata or vicus.*" This is the view which I have already presented; but a review of Stubbs' work in the North American Review (July, 1874), understood to be by the then editor of the Review, Prof. Henry Adams, takes exception to the assertion, saying that the township has no constitutional functions "of any kind, sort or description;" that the unit of the constitutional machinery in England, as on the continent, was the Hundred. "The one permanent Germanic institution," he says, "was the Hundred. The one code of Germanic law was Hundred law, much of which is now the common law of England. The Hundred and its law survived all the storms which wrecked dynasties and Witan. It was the foundation of the judicial constitution under the couqueror as it had been under Cnut and Alfred." The same view is repeated in Prof. Adams' "Essays on Anglo-Saxon Law," p. 32.

That the hundred was the lowest political division in Germany, as Prof. Adams asserts, admits of no doubt. This fundamental fact, together with the non-political character of the lower territorial divisions, is perhaps best formulated by Sohm,[1] who points out that the local governments in Germany were purely private corporations, having no public character or functions. But it does not follow that what was true of Germany was necessarily true of England. England, although a Germanic country, received in many respects a different development from Germany; and it is the essence of Bishop Stubbs' position that this was the case with the territorial organization below the Hundred. As the word "town" (*tun, tunscip*) is peculiar to England, so, it may be, is the thing designated by it. This distinction is supported by Von Maurer, the writer of highest authority upon the genesis of local institutions, who, in his *Einleitung zur Geschichte der Mark, Hof, Dorf und Stadtverfassung* (§ 145, p. 332), asserts that the English institutions differed fundamentally from the German in this respect. When, therefore, Prof. Adams says that such an institution as the one in question "would be quite at variance with all that we know of German law," he appears to stretch the argument from analogy further than is warranted. The very question at issue is whether the development of English institutions did not upon this point depart from German analogy.

I shall speak first of the territorial character of the English towns, and then of their political character; and shall try to show that we are to seek

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[1] The following passage expresses Sohm's theory with great fulness: *Zum grossen Nachtheil der Gesammtauffassung nicht blos der Verhältnisse des fränkishen Reiches, sondern der gesammten mittel-alterlichen Entwickelung wird die Thatsache in der Regel übersehen, dass, der Reichsverfassung der fränkischen wie der deutschen, eine Ortsgemeindeverfassung unbekannt ist. Die Reichsverfassung kennt keine weiteren Zwecke ausser denjenigen, deren Realisirung in Gau und Hundertschaft vor sich geht . . . Die Ortsgemeindeverfassung ist aus keinem anderen Grunde local für jede Ortsgemeinde verschieden, als weil die Ortsgemeindeverfassung aus der autonomen Entwickelung der einzelnen Gemeinden hervorgegangen ist. Die Ortsgemeindeverfassung ist Verfassung nur kraft Corporationsrechts, nicht kraft Reichsrechts. Sohm, (Altdeutsche Reichs und Gerichtsverfassung, I, p. 231).*

for analogies with them, not so much in the institutions of Germany, from which those of England were in a sense derived, as in those of New England, which are simply a continuation of those of England.

That the towns in England formed a complete territorial system as subdivisions of the hundreds, needs no argument, as it is amply attested by mediæval writers and documents. It is a familiar fact that they were regularly represented in the courts of the hundred and the shire. I will also cite the authority of Chief Justice Fortescue, in his *De Laudibus Legum Angliae*, who says that the Shires or Counties were divided into Hundreds, and the Hundreds into Towns or Vills (ch. xxiv). *Hundreda vero dividuntur per villas.* This language indicates clearly that "towns" were in the middle of the fifteenth century territorial divisions of the hundreds; that is, that the entire area of the hundred, and therefore of the county, was divided up into the areas of the several towns composing the hundred. And this is still further shown by his going on to say that under the appellation of towns, "the cities and boroughs are included. For the boundaries of these vills are not ascertained by walls, buildings or streets, but by a compass of fields, large districts of land, some hamlets, and divers other limits, as rivers, water-courses, woodlands and wastes of commons." It is evidently the intention of the writer in these words to contrast the English towns with some other towns, the bounds of which are determined not by natural objects, but by artificial ones; and this object of comparison can be only the walled towns and cities of the continent, especially of France, the country with which Fortescue constantly compares England. Attention is here drawn to the important fact that, whereas upon the continent the municipal system was sporadic, the open country having no institutions of local self-government proper, the English municipal system was continuous, embracing the entire territory of the country. The borough was, as Bishop Subbs says (vol. i, p. 92), "simply a more strictly organized form of the township;" and the city a bishop's seat, with borough organization. And both borough and city made, as Chief Justice Fortescue says, a part of the town system.

This town system was brought over to this country by our ancestors, and put in operation in all the northern colonies. The town system of New England, as a system of territorial areas, is the town system of mediæval England; and when the people of New England had outgrown the town system in its primitive form, they developed a new form of organization on precisely the same lines as the English. The New England "city" (and so the Pennsylvania "borough"), is simply a specially organized town, and forms a part of the town system, just as is the case with the boroughs and cities of Chief Justice Fortescue's difinition. A city is territorially a town. And here, as in the case of so many so-called Americanisms, we have preserved the old English usage, which has disappeared in England itself. The town, in its ecclesiastical organization, was a "parish," and in the sixteenth century the parish organization began to supersede the co-

ordinate town organization for purposes of local self-government.[1] It would seem that in the seventeenth century, when this country was settled, this process had not been completed. The colonists brought with them both institutions, and — as all New Englanders know — the parish and the town were, as a rule, identical in New England as in Old England. But while in New England the ecclesiastical organization became quite secondary, and has now practically disappeared, in Old England the reverse was the case. The parish organization has crowded out that of the town. As an English correspondent writes me: "With us town=market town"— a specially privileged, and I suppose specially organized, class of towns. The towns of the open country are known as parishes, and the functions of local self-government, so far as they continue to be kept up, are administered by the vestry, or parish assembly. Still even now we find a survival of the old usage. The same correspondent writes: "I am talking with the squire; the church bell sounds, and I ask him if he knows why: he replies 'for a parish meeting, I suppose.' Again, in a conversation with a laborer, to the same question he will reply: 'for a town meeting, I suppose, sir.'" Here the primitive term has lingered among the peasantry, while it has been dropped by the aristocracy.

The transition from town to parish, and the equivalency of the terms, as well as the fact of local self-government, to be considered further on, are illustrated by local documents. For example: in the reign of Edward VI., under the influence, I suppose, of the radical reformation of the church favored by that monarch, we have a record of a large amount of church plate and other property sold in the eastern counties, by the authority, as it is stated, sometimes of the town, and sometimes of the parish, showing that the two terms are employed as identical. For example: "Barkinge. Certifficat of Church wardens there. We present that we have solde by the consente of thole paryshe a crosse parcell gylte, etc. . . . to Robert Knappe and Roger Hylle of the same towne." "Beccles . . . solde anno primo Edwardi sexti Regis etc, by the Townshype and Churchewardens so moch plate as amounteth to the some of xl l." *East Anglian*, May, 1885. "Churchwardens of Martillesham. . . . goods sold by the said churche Revies and other the hoole Inhitants of the said towne." *id.*, March, 1887. This last instance appears to show an identity of the church-wardens with the mediæval reeve. At a later date we find the village of Exning (Suffolk), which at the close of the sixteenth century "appears" says the correspondent who mentions it, "to have been dignified with the title of 'Town', viz.,

1590.

"Item. pd the xx daye of Aprill for a quarter of wyne for the TOWN xij. d. etc." *id.*, March, 1888.

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[1] See Gneist's *History of the English Constitution*, Vol. ii, p. 196. As this great writer is wont to depreciate the popular elements in the English constitution, it is not surprising that he does not recognize the town, *villata*, as a regular part of the machinery of government in the middle ages.

It will be noticed that in these extracts the words "town" and "township" are used interchangeably. This was the case also in the early history of New England. For example: in the Massachusetts Body of Liberties (1641) we find "town" in Articles 16, 50, 51, 57, 62 and 85; "township" in Articles 66, 68 and 84, used with no apparent distinction of meaning. Article 74 couples them together: "the freemen of every town or township." We can perhaps trace a dispositiou to use the word "town" when speaking of the corporate body, and "township" for territory, e. g., Article 78, where it is forbidden to expend "any town treasure but by the freemen of that township." At present I believe the word "township" is not in use in New England, except occasionally to designate the town from the point of view of the territorial area; never as a body politic. Curiously enough, it is this word, fastened upon by De Tocqueville, that is regularly used by foreign writers to describe the New England *town* system. The term "*township* system" is properly used in this country only for the six-mile square divisions of the public lands, laid out by the government surveys. The states erected out of these public lands have a *town* system of their own, parallel with the national *township* system, and generally coinciding with it in respect to division lines, but not always. For example, the town of Trempealeau, Wis., contains the whole of Township 19, N., Range 9, W., and parts of Townships 17 and 18, Range 9, and 18 and 19, Range 10. In the primitive Anglo-Saxon usage the word "township," *tunscip*, appears to have been regularly used to designate the town as a municipality while "town," *tun*, was the settled portion — what in New England is called the "village" or the "middle of the town."

This distinction is quite in accordance with the etymology of the word. It is well known that "town," *tun*, is the same word with the German *zaun*, hedge or fence. But while the Germans never used the word *zaun* to designate the enclosed (fenced-in) area; the Anglo-Saxons, on the other hand, never used the word *tun* except to designate this enclosed area; the primitive meaning of *enclosing body* having been entirely lost. Now the thing fenced in was the village, or group of houses, which was accordingly the *tun*; and the *tunscip*, or township, was the area of land which belonged with the village as a municipal organization. As a consequence, the word *tun* was popularly applied to any place of collective residence; as where the Saxon Chronicle (Land Ms. An., 584), says: *Ceawlin manige tunas genam* — "Ceawlin took many towns." In the course of time the word *town* appears to have crowded out the more strictly correct word *township*, in the sense of designating the territorial area as a municipality; and in this sense the word was brought to New England by the colonists of the seventeenth century. In this country the meaning of the word is precisely that of Fortescue's time. In England, on the other hand, the modern use appears to be a survival of the loose and popular early usage, as applying to any place of collective residence; being limited in England at the present day to large places.

In limiting the signification of the word *tun*, to designate not the object which encloses (its primitive meaning), but the space enclosed, the Anglo-Saxon agrees with the Scandinavian language, as is the case with so many words and institutions of the early Anglo-Saxon period. The definition of the Icelandic *tun*, as given by Vigfussen, is: "a hedged or fenced plot, enclosure within which a house is built; then the farm-house with its buildings; the homestead." This is precisely the meaning which the word has in the earliest Anglo-Saxon laws, those of Aethelbihrt of Kent; it will be recollected that the settlers of Kent were Jutes, that is Scandinavians, rather than Saxons, like the rest of the migratory tribes. In these laws we read of a king's *tun* (Ch. 5), an eorl's *tun* (Ch. 13), and a "*mannes tun*" (Ch. 17) in all which cases *tun* is clearly the hedged enclosure, the homestead.[1] From the fenced enclosure of an individual homestead or field to that of a village, as in the later laws, is an easy step; or rather the two uses are alike easy transitions from the original signification of the enclosing fence or hedge.

This further extension of the word, however, does not appear to have been made by the Scandinavians of the continent any more than by the Germans. None of the Teutonic nations of the continent appear to have had any territorial subdivision of the hundred, of a substantial, individual, public character. With them the hundred was the unit of the constitutional machinery; and any lesser subdivisions stood to the hundred very much as our school districts or wards do to our towns or cities — as mere shifting administrative districts, having no substantial powers, and not forming a body politic. Scholars are now agreed, as I have already said, that the Dorfschaft was a division of a purely secondary character, for agricultural and economical purposes. Nevertheless it corresponded closely in its origin to the English *township*; and might, except for the early feudalization of Germany, have attained an equal degree of independence. *Dorf*, village, is the exact equivalent in meaning (not in etymology) of the English *tun*, and the affix *schaft* is the English *scip*; so that "township" is in meaning precisely the German *Dorfschaft*.[2]

From the territorial character of the English township, we pass to the consideration of its political character, as "the unit of the constitutional machinery." Direct evidence for this is not very abundant, but seems to be entirely sufficient. I have already spoken of Chief Justice Fortescue's mention of town (*villa*) as an integral part of the hundred, just as the hundred was an integral part of the shire. It is important also to note the well-known fact that the town (*villata*) was throughout the mediæval

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[1] This signification appears to have survived in Scotland; as, in Scott's Redgauntlet, Letter XI., where Darsie Latimer expresses a doubt whether he ought to go to Redgauntlet's "town" in disguise, the context showing that it is only his house that is meant.

[2] The German city of the middle ages was created not like the English borough, by giving higher powers to an already existing organism, but by cutting out a section of territory and bestowing upon it public functions of a municipal character. See articles by v. Below, *Historiche Zeitschrift*, 1888.

period the unit of representation[1] — and that not as a mere representative district, but as a body politic; for at this period representation was never of artificial divisions, but of corporate bodies. This is clearly a political or constitutional function. Such phrases as "by the consent of the saide Township," and "with the consent of the hole Towne," in the sales of church property mentioned above, imply organized and collective action — an assembly or "town meeting" of some sort.

That the township lacked the higher judicial powers is admitted by Bishop Stubbs, who says (p. 90): "their assemblies are rather gemots or meetings, than proper courts; for any contentious proceedings amongst men so closely connected and so few in number, must have been carried immediately to the hundred court." That the township did have a gemot or meeting, is proved by the mention of a *tunscipesmot* in a charter of Richard I., and that this meeting had certain definite powers of self-government, apart from its function as a unit of representation, is shown, for example, by the Costomary of Tettenhall Regis (English Gilds, p. 432), a body of regulations or "bye-laws" made by the tenants of the manor at their Leet or Law-day. This Costomary is a complete body of laws for the government of the community; and in the body of these laws the word "town" is twice used to designate the manor in its public relations.

"Art. 19. No man shall make yates or gapes in the common field, upon the corne or grasse of his neighbors, but by the consent of [the] comonty; and if he do, he shall give to the lord 2s., and to the comonty of the towne 2s."

"Art. 21. No man of oure towne shall enter upon the stubble of any other towne while the corne is upon the ground, except it is upon his own land, and by the good will of all his neighbors, under payne of iijs. to the lord."

In the passages just cited we have "town" used as equivalent to "manor," just as in those previously cited, it was used as equivalent to "parish." The manor was the feudalized township, that is, the township converted into a fief, as the parish was the township regarded as an ecclesiastical organization. And just as, in the sixteenth century, the parish, or ecclesiastical organization, superseded the township; so in the middle ages the manorial or feudal organization superseded, or at any rate obscured, the township, the original municipal division. This process of feudalization, or converting a free township into a seignorial estate, began very early in the Anglo-Saxon period. Indeed, even on the assumption that England was colonized by free peasants, organizing in free townships, we must at the same time admit the probability of a considerable proportion of seignorial townships, or manorial estates, side by side with the free communities, and intermixed with them. And whatever may have been the original status, it is certain that long before the Norman conquest,

[1] *Per quatuor legaliores homines de qualibet villata* (Assize of Clarendon, 1.)

there remained very few self-governing townships, composed of free peasants.[1] I do not consider the king's, eorl's and man's *tun* of Aethelbirht's Laws, to have been feudalized townships, at least not always or necessarily; they appear rather to have been farmsteads. But fifty years later the charters of the *Codex Diplomaticus* afford ample evidence of towns which were the private property of the King or powerful noblemen, the peasants or *ceorls* being their tenants and fast becoming their serfs, as I showed in my paper of last year.

The two-fold process here described, of converting the free townships into manorial estates, and the free peasants into servile tenants upon those estates, was consummated in the complete feudalization of England which followed the Norman conquest. Nevertheless the town organization was not obliterated, but only obscured. We have seen that it continued to serve as a basis for representation, and we have frequent mention of the town, *villa*, as the equivalent of the manor. The word *villa* is used about a dozen times Domesday Book, at least three of these times as equivalent to manor. E. g. (i. f. 199 b.) "Wluuin the thane held this manor. In the same town Reginald holds half a hide of Alberic." [So ii., 31 and 31b.] The Exeter Domesday and the Ely Inquest, documents which appear to be the rough draft from which the great record was made up, often use the word *villa* where the Exchequer Domesday says *manerium*, "manor."[1] But the two words are not used as equivalent, but rather as describing the same territorial area from different points of view. There might have been two manors in the same vill, or lands in the vill while were independent of the manor. Indeed it would naturally be the case that the manor would often vary from the town in respect to metes and bounds, while the parish or ecclesiastical organization would, like the town itself, be an unchangeable district. The manor, being a piece of private property, would be subject to the laws of private property, and would be divided, added to or diminished, through the processes of purchase, sale, inheritance and inter-marriage. So greatly have these processes changed the boundaries of manors, that it is stated that in East Kent there is only one manor co-extensive with the parish. (Academy, No. 167). We find, however, instances of this identification of manor and town as late as the sixteenth and seventeenth centuries. In the "Certificates of Church Goods in Suffolk," in the reign of Edward VI., is mentioned: "Mr. Sakford, lorde and patron of the Towne," evidently lord of the manor. In the time of the Civil Wars (1648), the Memoirs of Col. Hutchinson speak of Cromwell having "a design, by insinuating himself into Colonel Saunders, to flatter him into the sale of a town of his called Ireton." (ii., 137.)

When the town was feudalized and became a manor, its *gemot*, or meeting, seems to have become that branch of the manorial court known

[1] For examples, see paper upon "Village communities and serfdom in England."

[2] The Ely Inquest rests upon the evidence, among others, of *sex villani uniuscujusque villae.*

as the Court Leet. The Court Leet, found also in the Hundred and the Borough, was, as is shown by the example given above, an assembly for the passing of bye-laws and administering the affairs of the town, the precise prototype of the New England town meeting. It also had a limited police jurisdiction, held to be derived from that of the Sheriff's Tourn or Leet of the Hundred. It was not a necessary part of the feudal or manorial organization, but, "was created by special grants from the crown to certain lords of manor in order that they might administer justice to their tenants at home." Quoted by Elton, "Custom and Tenant Right (1882)," p. 89. It was a thoroughly democratic institution, "being regarded as the court of the residents within the district; not of the tenants of the manor;" and "so far is this carried that a stranger passing by may be compelled to serve on the leet jury. The fact of his being found within the district is deemed sufficient evidence." Digby, Int. to the Law of Real Property, p. 45. The Leet, as a popular court, is also found in Iceland during the middle ages. The antiquity and primitive character of this court is attested by Elton, who says (on Copyholds, p. 240) it "is in all probability older than the manorial system itself:" and by Ritson, "The Jurisdiction of the Court Leet," who says (p. 6): "The Leet is the most ancient court in the land." This court elected the constable, and, in some boroughs, the mayor (id. p. x.).

It is not surprising, considering their early and almost universal conversion into manorial estates, that we find so few traces of free townships in England. From their absence, Mr. Seebohm has attempted to establish the thesis that the townships of England were regularly manorial estates, and the peasants serfs, from the earliest settlement of the Anglo-Saxons in the country. "The evidence of the earliest Saxon and Jutish laws" he says, "thus leaves us with a strong presumption, if not actual certainty, that the Saxon *ham* or *tun* was the estate of a lord, and not of a free village community." (English Village Communities, p. 175.) I attempted in my paper, read a year ago to show that, with regard to the peasantry, his evidence was inadequate, and that we have good ground for affirming the existence of a large class of free peasants in the earliest time. My object in the present paper has been to continue the argument, and show that there is good reason to believe that there were free townships as well as a free peasantry in the earliest English period. In arguing, however, that the township was a body politic, and "the unit of the constitutional machinery." I would not be understood to claim for it original and self-existent autonomy, even in the period of the earliest evolution of institutions. Assuming that the Germanic peoples passed from a community of occupation based upon kinship to one based upon territorial relations; it was the Hundred, not the township, that formed the earliest territorial community or *markgenossenschaft*. The township, or *Dorfschaft*, is shown by Thudichum to have been formed out of the hundred by a process of sub-division; and in this process the German district thus formed succeeded to no integral share of the powers of the original organization, but stood to it as

ward to a city. The English district corresponding to it, on the other hand, became an autonomous community, with substantial and important, if not original powers.

The English town has therefore no counterpart in any other Germanic nation; for in all the other Germanic nations the unit of the constitutional machinery is the Hundred, a district too large to allow of this immediate and detailed exercise of local self-government which we find in the New England towns, and, as has been made to appear, in those of England. Much less has it any counterpart in the Celtic and Slavonic nations, which never advanced unassisted to the territorial principle of government; nor in the Romance nations, whose government, derived from that of the later Roman empire, was wholly summary and authoritative. On the other hand, the ancient Greeks and Italians — the only branches of the Aryan race which possessed an equally strong political sense with the Germanic — developed a territorial system which has a strong analogy with the English.

The City (*civitas*, πόλις), is the political type of the Greeks and Italians, as the Town is of the English: and while the two institutions diverged greatly in their development, they were essentially identical in their origin and structure. The Greeks, Italians and Germans alike passed from the social stage of institutions, based upon personal relations, to the political, based upon territory, at a very early period. In all of these we find the territory divided up into autonomous districts, small enough in extent to permit the direct participation of all the citizens in the work of government. The Greek City was thus identical with the German Hundred. But the development of all the Germanic nations, except the English, was arrested by the creation of great centralized monarchies. Even in England the more perfectly organized district, the Town, was shortly checked in its development by the establishment of the manorial system; and even where a higher municipal type was developed, in the boroughs, it was sporadic and thus incomplete.

The Greeks and Italians, on the other hand, concentrated and intensified their political life by what is known as *Synoikismos*,— the establishment in the middle of the territory of each city, of an *oppidum* or *urbs*, a place of collective residence, surrounded by walls, in which were erected their public buildings, and where they transacted all public and private business. This higher organization was applied to *all* cities, not merely to some here and there, like the English boroughs. These nations became urban in their life, while the English remained rural. But, in becoming urban, in building a city surrounded with walls for residence, trade, worship and social life, they did not shift the basis of their political organization. The city continued, as it had always done, to comprise the rural districts as well as the walled town; citizenship indeed was based upon ownership of land outside the walls equally with residence or property within the walls: the distinction between *rus* and *urbs* was purely social, in no sense political. Now the *oppidum*, inclosed within its walls, is very much the same thing as

the *tun*, enclosed with a hedge—a higher development upon the same general lines. But there was one point of contrast of vital moment. The Greek or Italian city, even if of no greater extent and population than an English town, was a sovereign state; the English town, however large and populous, was only a municipality, a part of a larger organism.

The word that is used in the Latin documents of the middle ages as meaning "town" is *villa* (or *villata*)—a word that has had a curious and interesting history. In classical Latin it means a country house—whether a farm-house, *villa rustica*, or a gentleman's country seat, *villa urbana*, in which sense it corresponds precisely to our modern word, *villa*. From meaning "house" it came by a not long or difficult transition, to mean the "estate" surrounding the house; and in this sense we find the word used in the later Roman empire. This was a period of great landed properties; but these properties, at least in Gaul, were not "plantations," *latifundia*, or vast and indefinite stretches of land, like the Dalrymple farm. Each great property was made up of a number of *villas*, not necessarily contiguous, each of these *villas* being a compact, organized estate of a moderate size. The small peasants' estates had for the most part disappeared, and Gaul at this epoch may be described as divided up into seignorial or domanial estates, corresponding roughly to the *communes*, or smallest territorial divisions of modern France. These *villas* agreed in many important particulars with the English manors, being perhaps of about the same extent, and being ruled autocratically by their owners.

The important fact to be noted here is the change in the significance of the word *villa*. From meaning a gentleman's country house, it has come to mean the estate depending upon that house; that is to say, it has acquired the meaning of a territorial district. And although the district thus designated in Gaul is a seignorial estate, it is easy, when the word has once become associated with the idea of an area of land, to extend its use to other districts of similar extent and grade. Thus we find it applied even on the continent to the *Dorfschaft* or village mark,[1] and in England it is used to designate the township, whether free or seignorial. But that it is the township that is thus designated, as a territorial area, and not the seignorial estate into which the township has been converted, is proved by the important fact, already noticed, that the manor and the township (*villa*) are not always identical. No argument, therefore, for the originally servile character of the English *tun* can be drawn from the fact that *tun* is in Latin *villa;* for although in Gaul a *villa* was a seignorial estate, in England it was not the estate as such, but an area of land, often identical with the manor, but often containing two or more manors, or parts of manors, or isolated pieces of land.

Thus the word *villa*, having acquired the signification of a territorial area, was used in England as the Latin equivalent of *Tunscip*. And as *villa*

[1] Van der Kindere, *Notice sur l'origine des magistrats communaux.*

was "*town*" — whether free or seignorial — so the cognate word *villanus* was "townsman" — whether free or serf. It is used regularly as the Latin equivalent of "ceorl," the free peasant of the early period, the semi-servile peasant of the later period, and the *villein* of the feudal period. When the ceorls lost their ownership of land, and their free status, their name sinking from the designation of a free yeoman to the opprobrious term "churl;" so the equivalent word *villanus* sank likewise, until it too, from meaning a free townsman, a member of the body politic, came to mean one who lived upon the land of another man, who was his master, paying for it by obligatory labor. And as "ceorl" has sank to "churl," so the honorable term *villanus* has sank to the opprobrious term *villain.*

A few words in conclusion, upon a subject more obscure in itself, and of more purely antiquarian interest — the connection of *tithing* and *township.* The word *tithing* is used as equivalent to *township* in some of the southern counties of England at the present day,[1] and it has been a matter of some controversy what is the origin of this territorial signification of the word, and how far back in time it dates. For the discussion of this question I will refer to Prof. H. B. Adams' excellent paper in the Johns Hopkins Studies, Vol. I, No. 4. It is admitted that there is no positive evidence of any but the numerical use of the word *tithing* in Anglo-Saxon times, as designating a group of ten men — *tenmanne tale* (Edv. Conf. xx) — formed for the purpose of enforcing mutual responsibility, as the fundamental principle of the system of the time for the preservation of the peace. The groups would seem at this period to have been strictly organized by tens. But after the Norman Conquest, under the more efficient *frithborg* system then established, the numerical value appears to have become a secondary consideration, and we very soon find a tendency towards localizing the term. Of course the original tithings were in a sense local; that is, each voluntary group of ten must have been composed of neighbors, and each township would naturally contain a number of such groups, none of them extending their membership beyond the bounds of the township. But in the thirteenth century (1284) we find, in the *Liber Niger* of the Monastery of Peterborough, a list of townships, each of which consists of a fixed number of tithings, varying, no doubt, according to the population. Of the town of Bartona we read (p. 109): *tota villata debet presentari per sex capitales decennarios* — the *capitales decennarii* being the "headboroughs" or "tithingmen." Other towns range from six of these officers to one, and we see the local character of the office in the fact that that they are the regular representatives of the town in the great court of the Hundred: (p. 113) *omnes libere tenentes et omnes capitales decennarii de predictis villis et foedis a tempore cujus non extat memoria, sc. ante tempus Willemi Regis Conquistoris . . . solebant venire bis in anno ad duas magnas curias que appellantur Turna vicecomitis, etc.* Now, it is evident that in the small townships which had only one tithing, it would be very natural and easy to identify the two terms, and

[1] Stubbs. Const. Hist. i, 85.

thus localize the word *tithing.* Of this we see further evidence in the Cartulary of the monastery of Gloucester. Vol. iii, No. 966, gives the items in the view of frankpledge in the Court Leet of the manor; among which we read: *de hiis qui sunt xii annorum, et non sunt in toethinga.* From this passage the tithing might appear to be a purely numerical group: but in No. 1,011 we read: *sunt tenentes in tethynga de Chirchesdona,* where the word tithing seems to have a clearly local value.

The passage from the numerical to the territorial signification is an easy one, and is illustrated by these passages. We see from the passage above cited that all boys of twelve were enrolled, not merely heads of families, as is sometimes assumed; and the same rule was observed in Anglo-Saxon times, as is shown by the law of Canute (ii., 20 *ofer xii wintra*). With the growth and order of good government, so large a number of groups as this came to be no longer necessary. Two centuries after the Conquest, we find small towns containing but one tithing, and the largest only six, which may perhaps have been divisions of its territory into wards or districts. From this condition of things the purely territorial meaning of the word in some parts of the country may easily have been derived.

My object in this paper has been partly to trace the origin and powers of the English town; partly to help to an understanding of its connection with the New England town. New England being colonized at just about the time that the parish organization was superseding that of the town in the mother country, it would seem, as I have already said, that the colonists, breaking away from the English ecclesiastical system, held to the town organization, making the parish purely secondary. The powers of the New England towns do not differ very widely from those of the English towns. We find, for example, in Russhemer, the "Implyments" of the money obtained by the sale of church goods to have been enumerated as follows:

towards the reparacioning of our churche - - - -	xl s.
ffurther to makyng of a pulpett & a lectern - - - -	xxiij s. iiij d.
also to the makying of a grett chest with locks - - -	iij s. iiij d.
Item to the pore peple of the parysshe - - - - -	xx s.
Also to the mendyng of the high weyes - - - -	xxiij s. iiij d."

East Anglier, July, 1887.

In other cases we find: "for ssyendyng fforthe of v Souldeors to the Kyngs Majesties warrs;" "in the wallyng of their marssh, in costs & chargs upon the havyn, And upon ther bulwerks of Gunnys. powder, & shotte for the defense & safegard of the town." : "to mainteyne a ffree scoole," etc.

These examples are taken from what I suppose to be small country villages, the prototypes of the New England towns. It may reasonably be supposed, however, that the boroughs, or higher class of towns, would give the example for the larger powers exercised by our more independent towns; and I find in the East Anglian (1886–8) a series of extracts from the records of the important town of Ipswich, as late as the time of the Com-

monwealth, which remind one, by the variety and minuteness of their functions, of those of the New England towns: for example, the hiring of preachers and teachers, as well as the care of roads, the supervision of markets, etc. The "Great Court" of Ipswich, consisting of "all the freemen, Portmen, Aldermen and Bailiffs," corresponds very closely to the New England town-meeting. The most characteristic feature of the New England town-meeting is, however, wanting—the requirement that the magistrates assume no control of the assembly, but retire into a private station, as it were, for the occasion; the meeting electing its own chairman, and exercising authority as a self-governing democracy. In most popular assemblies the magistrates are the presiding officers: in the English "vestry" or parish-meeting it is the parson, in the Great Court of Ipswich, one of the bailiffs. This feature of the New England town meeting, which, with others, it shares with the higher parliamentary bodies, may perhaps be claimed as another instance of the survival in America of usages or institutions which have become extinct in the mother country. Gneist says (p. 202): "The meeting was summoned by the churchwardens; the chair was regularly taken by the parson, as the landlord of the vestry, and the first member of the ecclesiastical parish, as a matter of courtesy, but a positive right of presiding could be established neither by precedent nor by analogy. In analogy with the tax-granting commoners, the meeting was rather regarded as its own master, in respect to the appointment of a chairman, as well as in respect to its adjournment. The voting was conducted with equal rights for each individual, after the manner of the old courts leet, the parliamentary elections, and the parliamentary resolutions. The mode of giving the vote was, as a rule, by show of hands, but in difficult and doubtful cases, by a poll."

My thesis, that the English towns of the middle ages were an integral part of the constitutional machinery, and not mere corporations, like the corresponding bodies of Germany, I have attempted to prove by showing: first, their territorial character, as conterminous areas of land, embracing the entire country; secondly, their practice of self-government in local concerns, and their organic relation to the larger representative bodies. We have seen that in the sixteenth century, at which time the parish became the organ of local self-government, the terms *town* and *parish* were used indifferently for the same institutions; and that in the seventeenth century, when the American colonies were planted, the colonists carried with them a *town-system* essentially the same as the *parish-system* which continued in England. The analogy with German institutions is misleading. The English people developed the institution of the "town" upon their own soil; and it is to be compared, not with the imperfect creation of the continental Germans, from which it was perhaps derived, but with the matured institution of New England, to which it gave birth.

REPTILIA AND BATRACHIA OF WISCONSIN.

By Prof. W. K. HIGLEY.

This list is not presented without a realization of the fact that some species may be omitted. If, however, any such are found, it is believed that they will be rare and local species, perhaps found in the outskirts of the state, which is subject to the migration of species from other regions. The Mississippi river forms an excellent pathway for the introduction of some strangers to our Reptilian and Batrachian fauna.

It is hoped that the present list will not only be found complete, but that the key may be found adequate for the determination of species.

The key is one that has been used in class work under the direction of the writer, and has been found sufficient for all local purposes. It has been arranged for the species of this state *only*, and, it is believed, in such a way that no new species will be reported that cannot be brought under its range, for in its preparation all extralimital species, liable to be found here, were included.

The classification followed is to a great extent that used by my friend, Dr. W. H. Smith, in the Herpetology of the State Survey of Ohio.[1] Dr. Jordan's "Manual of the Vertebrates" and the list reported by Dr. Hoy in our State Geology, have also been of great service, the former in the identification of species, and the latter both as a check list, and also as a source of information as to the range of some species, outside the districts from which the writer had identified specimens.

REPTILIA.

Animals having an epidermal covering in form of scales or plates which in one division become united with the bony skeleton forming an outside shield or shell; cold blood and an incomplete circulation; the heart three chambered in our species; the lungs large, consisting of but few cells; no metamorphosis; the respiration pulmonary throughout life.

KEY TO THE ORDERS OF REPTILES.

I. Epidermal covering united with the skeleton forming a shell which more or less completely covers the body; no teeth; anal opening roundish or longitudinal..... *Testudinata.*

[1] State Survey of Ohio, Vol. IV, Zoology and Botany.

I. Epidermal covering not united with the skeleton, scales or rarely plates; anal opening transverse; teeth present.
   a. Body much elongated, serpentiform; limbs wanting; mouth dilatable; eyelids none; no urinary bladder..... *Ophidia.*
   b. Body elongated; feet usually present; mouth not dilatable; eyelids usually present; urinary bladder present. ..... *Lacertilla.*

ORDER TESTUDINATA, TURTLES.

Body more or less perfectly inclosed in a bony or leathery shell-like case, plastron and carapace; epidermal plates usually quadrilateral in outline; animal variable in form, but generally short, thick-set or flattened; neck generally long allowing of considerable freedom of the head; the head, limbs and sometimes the tail may be completely withdrawn into the area of the shell; the bones of the skull finally became united by complete ossification; tongue thick; jaws forming a horny beak; food bolted; no teeth.

KEY TO FAMILIES OF TESTUDINATA.

I. Plastron very flat and divided into distinct parts which are so hinged, by two transverse divisions, as to form, with the carapace, a very perfect box; carapace very convex and deep; animal thickset; toes only slightly webbed; jaws not hooked or but slightly so; food mostly carnivorous..... *Cistudinidæ.*

II. Longitudinal section of the shell somewhat ovate in outline, caused by the position of the vital organs which are placed far forward, the carapace is thus higher anteriorly than posteriorly; plastron small and cruciform consisting of 12 plates; head and neck very muscular; jaws powerful and more or less strongly hooked; tail muscular with a ridge of horny obtuse or acute processes above, the longest often measuring more than an inch, and with two or more rows of scales underneath; very voracious and extremely fierce; mostly carnivorous and aquatic..... *Chelydeidæ.*

III. Longitudinal section of the shell ovate or oval, usually deepest near the center; edge of carapace obovate or oblong in outline, broadest posteriorly; plastron with 12 plates covering the entire under surface of the body, the anterior lobe sometimes hinged to the posterior; jaws not hooked, obtuse; carnivorous .... *Emydidæ*

IV. Body placed far back in the shell, causing an obovoid longitudinal section; carapace osseous, margins more or less reflexed underneath; plastron composed of a variable number of plates, seven, nine or eleven, and hinged, allowing the animal to more or less perfectly close its shell; head pointed; odor strong..... *Cinosternidæ.*

V. Shell orbicular or sometimes with an oval or oblong outline; covered by a leathery, more or less flexible skin; shell never fully ossified, and in some species with the ribs projecting; head long and conical..... *Tryonychidæ.*

FAMILY CISTUDINIDÆ, BOX TURTLES.

Represented by one genus and two species. Mostly carnivorous, and to some extent decidedly carrion eaters.

CISTUDO, Fleming.

C. clausa, Gmelin. Common Box Turtle.

Varies greatly in color; back ground always dark (black, brownish or drab) with yellowish spots or blotches; shell nearly oblong in outline; plastron sometimes truncate; anterior lobe the shorter, generally found in high but moist woods. Very rare. Two specimens have been reported from Walworth county.[1] Length of carapace about six inches; height about three inches.

C. ornata, Agassiz. Northern Box Turtle.

In many respects very similar to the last. Shell nearly orbicular and without keel. "Grant county; rare." Hoy: Walworth county.

FAMILY CHELYDRIDÆ, SNAPPING TURTLES.

Aquatic species of great strength, living in ponds and muddy streams. Represented by two genera and two species.

KEY TO THE GENERA OF CHELYDRIDÆ.

a. Head covered with skin; tail with two rows of scales underneath..... *Chelydra.*
b. Head covered with plates; tail provided with many scales underneath in several rows..... ..... *Macrochelys.*

CHELYDRA, Schweigger.

C. serpentina, L. Common Snapping Turtle.

Very common and well known.

MACROCHELYS, Gray.

M. lacertina, Schw. Mississippi or Loggerhead Snapper.

This ferocious turtle is occasionally found in the Mississippi river as far north as the mouth of the Wisconsin. Hoy.

FAMILY EMYDIDÆ, POND TURTLE.

The members of this family are generally very mild when approached, simply relying on the rapidity of their motions or by plunging into the water to effect their escape. Some forms (*Crysemys*), however, when taken in the hand, will snap quite savagely at the fingers.

Represented by five genera and six species.

KEY TO THE GENERA OF EMYDIDÆ.

a. Crapace more or less depressed or flattened; toes webbed; plastron broad and flattened, yellowish:
(a). Plastron movable on the carapace and divided, the anterior division being smaller and movable by a transverse hinge; plastron with irregular black spots..... *Emys.*
(b). "Upper jaw notched in front; shell not keeled in adult" (Jordan); toes strongly webbed; plastron immovable; carapace with outer plates *usually* marked with red..... ..... *Chrysemys.*

[1] Since writing the above, the author has identified specimens of *C. clausa* from Milwaukee, Pine Lake, La Crosse and Green Bay.

(a). "Upper jaw not notched in front; carapace more or less strongly keeled or tuberculated." (Jordan); toes strongly webbed; plastron immovable; lower jaw with a spoon-shaped dilatation..... *Graptemys*.

b. Web small; shell elongated, nearly oblong in form; plastron without hinge; carapace deep; black with or without orange or yellow spots which are round or oblong; upper jaw notched slightly; plastron light yellow with black irregular spots..... *Nanemys*.

EMYS, Brogniart.

E. meleagris, Shaw. Blanding's Box Tortoise.

Carapace dark colored with irregular yellow spots that are seldom absent. Terrestrial but generally found near water, to which they rapidly retreat if approached. Excellent swimmers. Common.

CHRYSEMYS, Gray.

C. marginata, Holb. Lady Turtle. Western Painted Turtle.

Neck, tail and legs striped with red; the plates of carapace variously marked with red or yellow. A beautiful species. Very common.

C. oregonensis, Holb. Plain Tortoise.

A form without red markings of *marginata*, is found occasionally in the western part of our state.

GRAPTEMYS, Agassiz.

G. geographica, Le Sueur. Map Turtle.

Streaked and reticulated with various shades of yellow upon a brownish back ground; neck and limbs quite gaily colored; carapace deeply notched posteriorly; aquatic; not common.

Probably this species is the most bold and active of this family. L. 9 inches.

G. Le Sueurii, Gray. Le Sueur's Map Turtle.

The characters distinguishing this from the preceding are not numerous but prominent. The colors are less striking in general, but the yellow markings are more intense; back ground grayer; each vertebral plate has a dark colored posterior which overlaps the succeeding plate; plastron clouded with brown or black; length of carapace 5-6 inches. Quite common in southern half of the state.

NANEMYS, Agassiz.

N. guttatus, Ag. Speckled Tortoise.

Carapace black with yellow spots scattered here and there; plastron with more or less black. But two specimens are known to me to have been found in this state. These were from Walworth county.[1]

FAMILY CINOSTERNIDÆ. CINOSTERNOID TURTLE.

Represented by one genus and species.

[1] Additional localities, reported after the above was written, Beloit, Madison, Eau Claire and other places, indicating that it is rare but generally distributed throughout the southern part of the state.

AROMOCHELYS, Gray.

A. odoratus, Latreille. Musk Tortoise.

Jaws strong; color dark with or without spots; head large with yellow spots on the side; a strong musky odor is always present; plastron black and yellow; marking more or less obscured by the adhering mud. Rare. Found in southern part of the state. I have found it in Walworth county.

FAMILY TRIONYCHIDÆ. SOFT-SHELLED TURTLES.

Represented by two genera and two species.

a. "Nostria terminal, crescent shaped" (Jordan); carapace with tubercles on the anterior margins..... *Aspidonectes.*

b. "Nostrals rather under the top of snout" (Jordan); no tubercles on the anterior margin of carapace. .....*Amyda.*

ASPIDONECTES, Wagler.

A. spinifer, Le Sueur. Soft-shelled Turtle.

The habits of this animal are such that they do not need hard shells for protection. Their color is not far from that of the mud of the streams in which they live. I have repeatedly passed by groups of them while dredging, without seeing them. My observations lead me to believe that they are generally found in groups. They are found in the southern and western parts of the state. Though not often met I believe them to be quite common.

AMYDA, Schweigger.

A. mutica, Le Sueur. Leathery Turtle.

Upper parts brownish; beneath, whitish without spots; anterior margin of carapace without spines or tubercles. This last character distinguishes it from the last. Found in the western half of the state and more common than the last, and with the same habits, though my observations lead me to believe that it is not so voracious.

ORDER LACETILIA. LIZARDS.

Body elongated or lacertiloid in form and covered by scales; limbs four (or two) or none; top of head covered with plates; tail quite long and generally brittle;[1] jaws with teeth, but they are not in sockets.

KEY TO THE FAMILIES OF LIZZARDS.

1. Tongue squamose, thick, fleshy, emarginate at the free extremity—free anteriorly and not protrusible; eyes medium size; eyelids scaly; scales quincuncially arranged; head subtriangular cephalic plates present and regular..... *Scincidæ.*

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[1] This serves as an excellent means of defense. It is very natural for one to catch the tail of a lizzard sooner than any other part because of its swiftness. The tail being very brittle it is no sooner touched than it breaks off. Jordan says this is owing "to a thin, unossified, transverse septum, which traverses each vertebra." I have had them lose their tails also when confined to close quarters.

2. Tongue palpillose, fleshy, emarginate and more or less free anteriorly; cephalic plates more scale-like or irregular; scales carinalted; head short; eyelids scaly..... ..... *Iguanidæ.*
3. Limbs not visible but present in a rudimentary state beneath the skin; ear distinct; lateral fold present; serpentine in form; cephalic plates quite large; abdominal region covered with square plates; tongue bifid..... *Arnguidæ.*

FAMILY SCINCIDÆ. THE SKINKS.

Represented by one genus and two species.

EUMECES, Wiegmann.

E. quinquelineatus, L. Blue-tailed Skink.

Color bluish-black with five yellow stripes, the dorsal stripe divides at the head sending a branch to each side of the vertical plate; beneath light blue; throat whitish; tail deep blue; the stripe disappears to a great extent with age: L. 7–8 inches; tail 4–5. Walworth County; rare.

I believe that this species will be found more common in all the southern counties, though it has not been reported to my knowledge. Its range is very extensive. It may be found to the best advantage in May, in dampish, unfrequented woods under bark.

E. septentrionalis, Baird. Northern Skink.

Olive with four darker stripes; two narrow lateral lines of white and black. Walworth County, "Not uncommon as far north as Lake Winnebago."[1] Hoy.

FAMILY IGUANIDÆ. THE IGUANAS.

Represented by one genus and one species.

SCELOPORNS, Wiegmann.

S. undulatus, Harlan. The Brown Swift.

Color brownish with irregular bands of black; greenish blue laterally; abdomen yellowish with dark spots; toes whitish; throat with skin more or less folded; L. 6 inches; rare. A few specimens have been reported from this state. I have not met it myself.

FAMILY ANGUIDÆ. THE GLASS SNAKES.

Represented by one genus and one species.

OPHISANRUS, Daudin.

O. ventralis, Daudin. The Glass Snake.

Color dark and yellowish with black streaks; quite common.

"In early days they were not uncommon near Kenosha. They occur in in the western part of the state as far north as La Crosse." Hoy.

[1] Since writing the above, the writer has examined several specimens from the western part of the state.

ORDER OPHIDIA. SNAKES.

Body covered with imbricated scales; beneath with a single row of band-like scales (gastrosteges) as far back as the anus. Represented in this state by two families.

KEY TO THE FAMILIES OF SNAKES.

1. Both jaws with ungrooved conical teeth; tail tapering, plates underneath (Urosteges) in pairs, without a rattle; no pit in front of the eyes; head more or less oblong, and usually tapering gradually into the neck..... *Colubridæ.*
2. No solid teeth, or but few in the upper jaw; jaw provided with grooved erectile poison fangs; tail provided with a rattle; Urosteges undivided, at least anteriorly; a pit in front of each eye; scales carinated; head separable from the body and more or less triangular..... *Crotalidæ.*

FAMILY CROTALIDÆ. THE CROTALID SNAKES.

Represented by two genera and two species. To this family belong some of the most deadly poison snakes.

KEY TO GENERA OF CROTALIDÆ.

a. Head covered with small scales, tail with large rattle..... .... *Crotalus.*
b. Head covered with nine large plates; tail with rather small rattle.. *Crotalophorus.*

CROTALUS, L.

C. durissus, L. Yellow Rattle Snake. Banded Rattle Snake.

Sulphur brown with darker in blotches or arranged, more or less regularly, in bands; head very triangular and ugly; dorsal scales in 23-25 rows; G. 170–180; U. 23–28; L. 3 to 5 ft. In rocky places; rare. Formerly this species was very common, but it is seldom met now. It may be found in the rocky bluffs of our larger rivers. Very poisonous.

CROTALOPHORUS, L.

C. tergeminus., Holb. Massassauga or Prairie Rattlesrake.

Color brownish, "Spots of dark brown margined with black, and exterior to this a still lighter circle; vertebral blotches, 34 in number, almost quadrate, notched in front and behind, and extending from neck to tail; 2 to 3 series of lateral blotches on each side varying from circular to oblong" (Smith). There are other series of lighter lines, but the above will be sufficient to determine the species. Dorsal scales 25 rows; G.140–150; U. 25–30; L. 2–3 ft.; not rare; in grassy marshes throughout the state. Poisonous.

Variety Kirtlandii, Holb.

Much darker and more uniform, with darker blotches above. Walworth county; rare. W. H. Smith in the State Survey of Ohio says,*— "The

* Vol IV, p. 674.

specimens of *C. tergeminus* which I have seen from Wisconsin, have a broader head and the transition from the head to neck is more abrupt than in Illinois or Ohio specimens."

It is safe to assume, then, that all snakes that have a triangular head, that may be met in this state, are to be avoided.

FAMILY COLUBRIDÆ. THE COLUBRINE SNAKES.

Represented by eleven genera, twenty species and several varieties.

The following Key for the determination of the genera is a modification of that used by Jordan, Smith, and others.

	Dorsal scales carinated, a.	
	Dorsal scales smooth, i.	
a.	Post-abdominal scutella entire, b.	
a.	Post-abdominal scutella bifid, c.	
b.	Dorsal rows of scales not exceeding 23	*Entœnia.*
b.	Dorsal rows of scales exceeding 25	*Pityophis.*
c.	Loral and anteorbital plates, both present, d.	
c.	Lorals absent	*Storeria.*
d.	Dorsal rows of scales, 19 or more, e.	
e.	Cephalic plates typical, f.	
e.	Cephalic plates not typical, large, h.	
f.	Post-orbitals three, rarely two; ante-obitals usually one; dorsal rows of scales, 23-29	*Tropidonotus.*
f.	Post-orbitals two; dorsal rows of scales, 19-21	*Regina.*
h.	Muzzle projecting and recurved	*Heterodon.*
h.	Muzzle not projecting	*Coluber.*
i.	Ante-orbital plates both present, j.	
j.	Post-abdominal scutella entire or bifid; dorsal rows of scales 25	*Ophibolus.*
j.	Post-abdominal scutella bifid; dorsal rows of scales not exceeding 21, k.	
k.	With yellow ring around the neck	*Diadophis.*
k.	Without a ring around the neck, l.	
l.	Dorsal scales in 15 rows	*Liopeltis*
l.	Dorsal scales in 17 or more rows	*Bascanion.*

EUTÆNIA, B. & G.

Our most common snakes; terrestrial; ground color dark; one vertebral and two lateral stripes; gastrosteges 140–170; urosteges 50–120; dorsal rows of scales 19.

It is believed that the following Key will enable one to trace any species or form commonly found, though great variations in the markings exist.

(a)	Lateral stripe on the third and fourth rows of scales; body slender; tail nearly one-third of total length, (b).	
(a)	Lateral stripe on second and third rows of scales; body stouter; dorsal band on one and two half rows of scales; tail one-fourth of total length; G. 132-170; U. 55-80	*Sirtalis.*
(a)	Scales rough; stripes all narrow; lateral not usually over a scale in width, placed on part of two rows; six or seven series of brownish or blackish spots; outer row of scales often very broad	*Radix.*

(b) Occipital plates with a yellow spot; upper labials eight; dorsal band on one and two half rows of scales; lateral stripe on third and fourth rows; G. 165–180; U. less than 110. .... *Proxima.*

(b) Orbital plates yellowish; upper labials seven on each side; dorsal line on about one row of scales terminating at posterior margin of the occipital plate; G. 175–180; U. 115 or more. ..... *Saurita.*

E. sirtalis, L. Striped or Garter Snake.

Ground color, blackish; dorsal band yellow; lateral band yellowish; abdomen greenish; occipital plate sometimes with two yellow spots; upper labials 7 or 8; offensive when handled; L. 2–2¼ feet; tail about 6 inches; abundant.

Variety dorsalis, B. & G.

Dorsal stripes broad and marginal on each side with black in one row of scales; lateral stripe with a row of dark spots above; common.

Variety parietalis, B. & G.

Dorsal stripe medium; brick red spots in lateral bands; not rare.

Variety ——— with dorsal stripe absent, yet with all the characters of the typical form present. Walworth county; rare.

Dr. W. H. Smith suggests for this variety the name *melanota*.

E. radix, B. & G. Hoy's Garter Snake.

General color above black, with three very narrow yellow lines; head short; L. 2–2½ feet; G. 150–165; U. 53–85. Not rare.

E. saurita, L. Swift Garter or Ribbon Snake.

Slender; tail very long and slender, pointed; color dark brown; stripes extending the whole length, but indistinct in the tail and sometimes becoming obsolete near the end; dorsal and upper edge of lateral lines with blackish or brownish margins; under parts greenish; L. 2½–3 feet; tail 9 inches; southern part of the state in damp woods; not rare.

Variety faireyi, B. & G. Fairie's Garter Snake.

Occipital plates with two yellow spots; lateral line margined on both sides by black; same range as the last; not common.

E. proxima, Say. Say's Garter Snake.

Ground color black; beneath whitish to olivacous, dorsal band yellow or darker; lateral greenish or whitish; beneath lateral strip lighter than above; L. under 3 feet; tail under 9 inches; southern half of the state; not rare.

PITYOPHIS, Holbrook.

P. sayii, Schl. Western Pine Snake.

"Whitish or reddish with many dark blotches and spots; dorsal scales usually 25 rows. G. 220–230; L. 40–70." Jordan.

"A large species; in early days it was common in the western part of the state; now rare." Hoy.

L. 4–11 feet; reported from northwestern counties; rare; large specimens very rare.

STORERIA. B. & G.

KEY TO THE SPECIES OF STORERIA.

(a) *Scales* 15 *rows;* belly red; G. 120-128; U. 40-50; Anteorbitals two; upper labials 5 or 6; lower 6 or 7.... .... *occipito-maculata.*

(b) *Scales* 17 *rows;* under parts greenish or nearly white; G. 120-140; U. 46-60; upper and lower labial plates 7..... ..... *dekayi.*

S. occipito-maculata, Storer. Red-bellied Snake.

General color above grayish or brownish, with (usually) or without a dorsal band margined by darker spots; L. 9–15 inches; tail about 2 inches; common througout the state.

S. dekayi, Holb. Little Brown Snake.

General color grayish brown; dorsal stripe lighter margined by dotted lines; a black line from the occipital plate to the angle of the mouth; one or two black spots below the eyes; L. 12 inches or less; tail about 2; southern part of the state; not rare.

TROPIDONOTUS, Kuhl.

Our species have eight upper and ten lower labial plates; these are large and prominent; aquatic habits; food mostly fish and other water animals.

KEY TO THE SPECIES OF TROPIDONOTUS.

(a) *Dorsal scales* 27 *rows; outer row smooth;* above with quadrangular dark spots about 48 or 50 in number, and reaching to the end of the tail .... *rhombifer.*

(b) *Dorsal scales* 23 (variety with 25); above with three series of dark blotches, the dorsal row larger than the others; abdomen irregularly marked with yellow and brown ..... *sipedon.*

(c) *Dorsal scales* 23; *under parts* copper colored; head large, triangular; general color above, reddish black without spots or blotches.....*erythrogaster.**

T. rhombifer, Hallowell. Holbrook's Water Snake. Water Adder.

General color, brown; L. 2½–3 ft.; G. 140–145; U. 63–74; tail about 6 inches; unfrequented damp places; rare; Walworth county.

T. sipedon, L. Water Snake. Water Adder.

General color brownish; markings sometimes obscure in old specimens; young with markings very decided, but with some variations in their colors; body large; carnivorous, living almost entirely on fish; L. 3–4 ft.; tail 10–13 inches; G. 150–155; U. 65–80; southern counties; not common.

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* *T. erythrogaster*, Shaw. Since this report was presented to the Academy, I have seen two specimens of this species; one from near Beloit, and the other from Lake Geneva. Rare.

REGINA, B. & G.

Habits aquatic or terrestrial; dorsal scales in 19 rows.

KEY TO THE SPECIES OF REGINA.

(a) Ante-orbitals two; upper labials, 7; lower, 8; beneath yellow; three black dorsal and a yellow lateral band ..... *leberis.*

(b) Ante-orbitals one; *beneath brick red*, with dark near the exterior of the scutellæ; upper labials, 6; lower, 7..... ..... *Kirtlandii.*

(c) Ante-orbitals two; beneath, yellowish; upper labials, 7; lower, 8; above, brownish; dorsal line lighter and bordered with black; lateral line yellow, bordered with dark, in first second and third rows .... *Grahamii.*

R. leberis, L. Yellow-bellied or Leather Snake.

Above, brownish; lateral band on the first and second rows; L. 2–2½ ft.; tail 5–6 inches; G. 140–150; U. 65–80; not common.

R. kirtlandii, Kennicott. Little Red Snake.

Above brownish or purplish brown with irregular blotches in four rows, the outer being the larger; L. about 1 ft.; tail about 3 inches; G. 120–140; U. 55–65; Walworth county, and probably throughout southern counties; rare.

R. Grahamii, B. & G. Graham's Snake.

Scales strongly carinated; lateral line broad; L. 1½–2 ft.; tail 3–4½ inches; G. 160–165; U. 57; mostly in western countries; not rare.

HETERODON, Beauvois.

Body quite thick set and can be dilated at will of the animal by inhalation of air; hissing very peculiar and characteristic, similar in sound to the rattle of the rattlesnakes; head triangular. These snakes have a strong resemblance to venomous species, when angered or disturbed, flattening their bodies and head and hissing in a very threatening manner. Odor very marked and unpleasant.

H. platyrhinus, Latreille. Hog-nose Snake. Blowing Viper. Spreading Adder.

Above brownish with 28–30 dark dorsal blotches varying from quadrate to circular; lateral blotches irregular; these blotches become rings on the tail; *vertical plate longer than broad;* beneath, slate color and varying on post-abdominal region from yellow to reddish; upper labials yellow; dorsal scales 25 rows (usually); G. 125–150; U. 45–50; L. 2½–3 feet; tail 7–8 inches; on sandy or dry localities as far north as Madison; not common.

Variety niger, Catesby. Black Viper.

Uniform black or brown above without spots; said to be more ferocious than the type but is harmless; about the same range as the last; rare.

H. simus, L. Hog-nosed Snake.

General color lighter and more yellow than the last species; about 32–35 dorsal blotches; *vertical plates broader than long;* interfrontal region with 4–8 small plates; dorsal scales 23–27 rows; L. 2½–3 feet; G. 130; U. 45–55; sandy localities throughout the state; not rare.

COLUBER, L.

Body large; head elongated; ante-orbitals one; post-orbitals two; mouth deeply cleft; upper labials 8, lower 11.

KEY TO THE SPECIES OF COLUBER.

(a) Dorsal scales 25 rows; color above light brown with more or less quadrate, chocolate colored blotches in three rows, the dorsal two or three times larger than the lateral; head light brown or yellowish above..... *vulpinus.*

(b) Dorsal scales 27 (usually); color black and shiny; scales often margined with yellowish; head black above..... ..... *obsoletus.*

C. vulpinus, B. & G. Fox Snake.

Vertical plate broader than long; abdomen with colors in blotches; L. 5 feet; tail about 10 inches long, large at the base; prairies throughout the state; food, small vertebrates and insects; not rare.

C. obsoletus, Say. Pilot Snake or Racer.

Upper labials yellowish; beneath darker and more or less mottled with yellow, black and whitish; vertical plate longer than broad; dorsal scales 27 rows (usually); L. 4–6; tail 10–11 inches; G. 230–235; U. 80–85; found throughout the state in timbered districts, but is not common.

Feeds on squirrels, birds, bird's eggs, etc.; is somewhat arboreal in its habits. The larger forms are very rare.

OPHIBOLUS, B. & G.

O. triangulus, Boie. Milk Snake.

Local names numerous and various. General color grayish with three series of black margined brown blotches, the dorsal row numbering about 50, and elliptical to oval in shape; lateral spots in two rows, varying in size; head with two blotches above; blotched beneath; dorsal scales in 21 rows; G. 200–210; U. 48–55; L. 3–4 ft.; tail 5–6 inches; varies greatly; habits carnivorous; common.

DIADOPHIS, B. & G.

D. punctatus, L. Ring-necked Snake.

Bluish black (or darker) above, without spots; occipital region with yellow ring or spots; beneath orange or lighter, each plate generally having a dark spot; head depressed; dorsal scales 15 rows; G. 140–165; U. 35–58; L. 1½ ft.; tail about 3 inches, found under stones or bark of decaying trees; odor strong; not rare.

LIOPELTIS, Fitzinger.

L. vernalis, De Kay. Green or Grass Snake.

Body slender; head elongated; color above bright and uniform deep green; lighter or yellowish beneath; L. 1–1½ ft.; tail about 4½ inches; G. 129–140; U. 70–98.

A beautiful species, very lively in its movements; insectvorous. Common throughout the state in damp places, and may often be seen in the morning when there is dew on the grass.

BASCANION, B. & G.

B. constrictor, L. Blue Racer or Black Snake.

Varies in color; our form varies from azure blue to blue-black; beneath greenish; mouth deeply cleft; head elongated; dorsal scales smooth and usually in 17 rows (sometimes 19); L. 4–6½; G. 170–205; U. 80–115; southern part of the state; not common.

This form varies considerably from the Black Snake of the east in its color, which is often a very intense azure blue; especially immediately after moulting. Dr. W. H. Smith suggests that this form might well be made a variety with the very appropriate name of *cœruleus*.

BATRACHIA.

Body always without true scales and covered by a smooth skin; metamorphosis after birth and usually complete; respiration branchial in the young, and either pulmonary or both pulmonary and branchial in the adult; heart with two auricles and one ventrical; circulation incomplete.

KEY TO THE ORDERS OF BATRACHIA.

I. Body thick set and when adult without a tail; the posterior limbs much longer than the anterior and developed first in the metamorphosis; skin smooth, granular or warty; tongue free behind and can be protruded with great rapidity..... *Anura.*

II. Body elongated; the four limbs very widely separated, short and of nearly equal length; tail, persistent and usually long; tail compressed or terete; fore limbs developed first in the metamorphosis; motions more or less snakelike..... *Urodela.*

ORDER ANURA. TAILLESS AMPHIBIANS.

KEY TO THE FAMILIES OF ANURA.

1. Posterior toes webbed; anterior toes more or less webbed; upper maxillary and vomer-palatine teeth present; skin smooth, or essentially so; posterior limbs exceeding the length of the body and much longer than the anterior; tympanum distinct and prominent; fingers not dilatable; tongue emarginate at free extremity; live near water..... *Ranidæ.*

2. Toes more or less webbed; upper maxillary and vomer-palatine teeth present; tympanum distinct; fingers and toes with disks at their tips; skin more or less granulated; tongue usually simply notched at the free extremity; chiefly arboreal..... *Hylidæ.*
3. Toes webbed; posterior limbs hardly as long as the body; skin usually warty; tympanum small and not apparent; jaws without teeth; tongue entire at free extremity; terrestrial, nocturnal, and insectivorous..... *Bufoniedæ*

FAMILY RANIDÆ. THE FROGS.

Represented by one genus and five species.

The following is a key to species of the genus:

RANA, L.

(a). Dorsal region with *large* and distinct irregular dark spots in usually two (rarely more and these scattered) rows upon a greenish or brownish background; beneath very white or yellowish; eyes prominent and usually with two dark blotches between them[1] ..... *halecina.*

(b). Dorsal region with or without *small* dark spots:

(1). Color green or brown; irregularly spotted (or speckled) on the legs and sides with dark which may reach to the dorsal region; beneath white to yellow; irides yellow..... *clamitans.*

(2). Reddish or greenish brown; a dark line passes through the tympanum and eye, often reaching to the nostrils; legs usually barred or blotched with dark above; tympanum small; beneath yellowish or whitish. *temporia, var. sylvatica.*

(3). Greenish brown with dark irregular spots which are conspicuous on the legs and sides; beneath yellowish, often mottled with dark brown; tympanum large; animal very large and muscular; pupils black; irides green ..... *Catesbyana*

R. halecina, Kalm. Leopard Frog.

L. 3 to 4 inches; posterior limb 6 inches; in wet places and especially in marshes and along streams; common.

R. clamitans, Daudin. Green or Spring Frog.

Thighs granulated posteriorly; L. 2-3 inches; posterior limb about 4 in.; anterior limb about 1½ in.; common along brooks and ponds; often in wet weather may be found wandering to some distance from any stream.

R. temporania, L. Var. sylvatica, Le Conte. Wood Frog.

L. 2 inches; posterior limb about 2½ in.; anterior limb about 1½; in damp woods among leaves; not rare.

R nigrescens, Ag. Black Frog.

Prof. Agassiz determined a specimen caught at Racine as the *Nigricans;* Rare." Hoy.

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[1] *R. palustris* has the dorsal spots usually square, in four rows with smaller spots scattered irregularly outside.

Having no description, and never having seen this form, I am unable to place it in the Key. Some of our authorities, however, consider it merely a form of *clamitans.*

R. palustris, Le Conte. Marsh or Tiger Frog.

This is quite common in Michigan, and may possibly be found in Wisconsin; L. 2–3 inches; posterior limb about 4; anterior limb about 1½.

FAMILY HYLIDÆ. TREE TOADS.

Represented by two genera and four species.

KEY TO THE GENERA OF TREE TOADS.

a. Toes nearly or quite distinct; fingers quite distinct; disks small; body slender; tongue emarginate behind..... *Chorophilus.*

b. Toes webbed; fingers more or less webbed; disks large; body often thick set; tongue, if at all only slightly emarginate behind..... *Hyla.*

CHOROPHILUS, Baird.

C. triseriatus, Wied. Little or Striped Tree Frog.

Color bluish ash or blackish; more or less striped; skin with granulations; no warts; toes with trace of web at the base; L. 1 to 1½ inches; posterior limb about twice as long as the anterior.

"*C. maculatus*, Ag. Spotted Tree Frog.

Found on Lake Superior." Hoy.

HYLA, Laurenti.

H. versicolor, Le Conte. Common Tree Toad.

"Patches of vomerine teeth slightly elevated; tongue slightly notched behind." W. H. Smith.

Color varying from green to brown with irregular spots; below dirty white to yellow, seldom spotted; common.

"*H. pickeringii*, Holb. Pickering's Tree Toad, abundant." Hoy.

"Patches of vomerine teeth not elevated; tongue truncate behind;" W. H. Smith. Reddish or yellowish brown; spots dark, rhomroidal; lines dark, and sometimes cuneiform in arrangement.

FAMILY BUFONIDÆ. THE TOADS.

Represented by one genus and one species.

BUFO, Laurenti.

B. lentiginosus, Shaw. Var. *Americana*, Le Conte. Common Toad.

Body warty and very rough when adult; color cinereous and brownish; speckled; below yellowish or dirty white; tympanum not very apparent; pupils black; very common.

ORDER URODELA. TAILED AMPHIBIANS.

KEY TO THE FAMILIES OF URODELA.

1. Gills persistent.... ..... *Proteidæ.*
2. Gills caducous; gill slit closed in the adult..... ..... *Salamandridæ.*

FAMILY PROTEIDÆ. THE MUD PUPPIES.

Represented by one genus and one species.

MENOBRANCHUS, Harlan.

M. lateralis, Say. Mud Puppy. Dog Fish. Water Dog.

Body cylindrical and smooth; general color brownish with spots of darker; a black lateral line is sometimes present; gills red and bushy, in three groups on each side; tail compressed; nocturnal and aquatic, living but a few moments on land; L. 1 to 2 ft.; common and carnivorous.

FAMILY SALAMANDRIDÆ. THE SALAMANDERS.

Represented by five genera and eleven species.

KEY TO THE GENERA OF SALAMANDRIDÆ.

a. Tongue fleshy, attached by the center, the lateral and anterior margins being free; costal grooves very distinct; vomero-palatine teeth transversely arranged; posterior toes, 5; color dark; skin smooth with numerous pores; tail compressed ....*Amblystoma.*

b. Tongue attached by the anterior and posterior edges, a small part of the lateral being free; costal grooves indistinct; vomero-palatine teeth longitudinal and divergent behind; posterior toes, 5; tail compressed from the base; colors bright. ....*Notophthalmus.*

c. Tongue roundish, the anterior edge and center attached, the lateral and posterior free; vomerine teeth in two patches; posterior toes, 5; general color dark; tail tapering to tip..... ....*Plethodon.*

d. Tongue oval, attached by the anterior edge; *toes, four in front and behind;* costal grooves distinct; general color above brown; beneath white with black spots; tail, long, round at the base and then compressed ....*Hemidactylium.*

e. Tongue attached by the center, the entire edge being free (boletoid) costal grooves distinct; vomerine teeth in a tranverse row; posterior toes, 5; color yellowish or red; tail long, tapering and compressed....*Spelerpes.*

AMBLYSTOMA, Tschudi.

A. opacum, Gravenhurst. Blotched Salamander.

Color above dark with tranverse bluish gray bars or blotches; head with a triangular spot; below slaty; costal furrows or grooves, 11; no large pores on head. L. about three inches; tail about 1½ inch; rare. "Racine." Hoy.

A. punctatum, L. Large Spotted Salamander.

Black or nearly so with bright yellow spots arranged along each side on the dorsal furrow, which is quite distinct; skin with numerous pores which are enlarged and arranged in two patches on each side of the head; costal furrows or grooves, 11; L. 6 inches; tail, 2½ inches; southern part of the state; not common.

A. tigrinum, Green. The Great or Tiger Salamander.

Everywhere dark with yellow spots which are either round or irregular; costal furrows or grooves, 11; dorsal groove quite distinct; head depressed; L. 7 inches; tail 3 inches; common.

A. jeffersonianum, Green. The Granulated Salamander.

Variable; in general brownish or blackish with ashy spots, but "sometimes uniform plum" (Jordan); costal furrows 13; the furrows on the tail extending nearly to the tip; L. 3 to 4 inches; tail 1-2 in.; Walworth county; rare. Dr. Hoy reports them from Racine. I have reason to believe that they may also be found in the extreme northern part of the state.

NOTOPHTHALMUS, Raf.

N. viridescens, Raf. Common Spotted Triton. Newt. Eft.

Color: olive to scarlet above, and orange to red underneath (variable); spots on sides, vermillion enclosed in a black ring and usually in a line; beneath with black dots; costal grooves about 14. *H. miniatus*, Raf. I believe to be the same species, and I have included its characters in the above description. I have seen the two forms at the same pond during the breeding season, and have also noted gradations in color between the two extremes. It seems to me highly probable that age has something to do with the darker color; L. 3-4 inches; tail 1-2; common in brooks and ponds.

PLETHODON, Tschudi.

P. erythronotus, Green. Red Backed Salamander.

Dorsal stripe red, extending nearly the whole length of the animal; sides cinereous; head brown above; lower jaw whitish; costal grooves or furrows 16 to 19; caudal grooves 18–22; L. 3–4 inches; tail 1–2; southern Wisconsin; not rare.

Variety cinereous, Green.

Without the red dorsal stripe. This form may be met, and I have placed it here as a variety merely to aid in identification for it would seem from the investigations of our best authorities that the changes are simply those wrought by age.

Their food consists of snails, worms and insects.

P. glutinosus, Green. Gray Spotted or Viscid S.

Above glossy black with very small gray spots; lateral spots larger; costal furrows 14; spotted below; in moist places; color varying with age, there being fewer spots on old specimens; not common.

HEMIDACTYLIUM, Tschudi.

H. scutatum, Schlegel. Four-toed Salamander.

"Color above, brown, muzzle yellowish, limbs and tail orange brown; upper surface with black spots on each side scattered irregularly; beneath white with patchy black spots," Smith. Rare; "Racine." Hoy. Habits, Insectivorous.

SPELERPES, Rafinesque.

S. ruber, Daudin. Red Salamander. Red Triton.

Color above, intense red with small roundish black spots; color less marked beneath; head triangular; costal grooves 14-16; L. 5 inches; tail about 2; in damp and unfrequented swamps of southern half of state; not rare.

S. longicaudus, Green. Cave or Long Tailed S.

Yellow spotted with dark; below spotless, yellowish; head oval; costal furrows 13; L. 5 inches; tail 3–3½ inches; Walworth county; Racine," Hoy; rare.

S. bilineatus, Green. Stripe-backed Salamander.

Yellowish or darker with two (or three) longitudinal black lines; below yellowish and unspotted; costal grooves 14; L. 2–3 inches; tail 1½ inches; two or three specimens have been reported from southern Wisconsin, "Racine," Hoy; rare.

REFERENCE AND CHECK LIST OF THE REPTILIA AND BATRACHIA OF WISCONSIN.

REPTILIA.

LACERTILIA.

SCINCIDÆ.

Eumeces quinquelineatus, L. Blue-tailed Skink.
Eumeces septentrionalis, Baird. Northern Skink.

IGUANIDÆ.

Sceloporus undulatus, Harlan. Brown Swift.

ANGUIDÆ.

Ophiosaurus ventralis, Daudin. Glass Snake.

OPHIDIA.

CROTALIDÆ.

Crotalus durissus, L. Yellow Rattlesnake.
Crotalophorus tergeminus, Holb. Prairie Rattlesnake, or Massassauga.
Crotalophorus tergeminus, Var. kirtlandii, Holb. Massassauga.

COLUBRIDÆ.

Eutænia sirtalis, L. Common Garter Snake.
Eutænia sirtalis, Var. dorsalis, B & G.
Eutænia sirtalis, Var. parietalis, B & G.
Eutænia sirtalis, var. melanota, Smith.
Eutænia radix, B. & G. Hoy's Garter Snake.
Eutænia saurita, L. Swift Garter or Ribbon Snake.
Eutænia saurita, Var. faireyi, B. & G.
Eutænia proxima, Say. Say's Garter Snake.
Pityophis sayii, Schl. Western Pine Snake.
Storeria occipito-maculata, Storer. Red-bellied Snake.
Storeria dekayi, Holb. Little Brown Snake.
Tropidonotus rhombifer, Hallowell. Holbrook's Water Snake.

Tropidonotus sipedon, L. Water Snake, Water Adder.
Regina liberis, L. Yellow-bellied or Leather Snake.
Regina kirtlandii, Kenicott. Little Red Snake.
Regina grahamii, B. & G. Graham's Snake.
Heterodon platyrhinus, Latr. Blowing or Spreading Viper.
Heterodon platyrhinus, Var. niger, Catesby. Black Viper.
Heterodon simus, L. Hog-nosed Snake.
Coluber vulpinus, B. & G. Fox Snake.
Coluber obsoletus, Say. Pilot Snake or Racer.
Ophibolus triangulus, Boie. Milk Snake.
Diadophis punctatus, L. Ring-necked Snake.
Liopeltis vernalis, DeKay. Green or Grass Snake.
Bascanion constrictor, L. Blue Racer. Black Snake.

TESTUDINATA.

CISTUDINIDÆ.

Cistudo clausa, Gmelin. Common Box Turtle.
Cistudo ornata, Ag. Northern Box Turtle.

CHELYDRIDÆ.

Chelydra serpentina, L. Common Snapping Turtle.
Macrochelys lacertina, Schw. Mississippi or Loggerhead Snapper.

EMYDIDÆ.

Emys meleagris, Shaw. Blanding's Tortoise.
Chrysemys marginata, Holb. Lady Turtle.
Chrysemys oregonensis, Holb. Prairie Turtle.
Graptemys geographica, Le S. Map Turtle.
Graptemys lesueurii, Gray. Le Sueur's Map Turtle.
Nanemys guttatus, Ag. Spotted Turtle.

CINOSTERNIDÆ.

Aromochelys odoratus, Gray. Musk Turtle.

TRIONYCHIDÆ.

Aspidonectes spinifer, Le S. Soft-shelled Turtle.
Amyda mutica, Le S. Leathery Turtle.

BATRACHIA.

ANURA.

RANIDÆ.

Rana halecina, Kalm. Leopard Frog.
Rana clamitans, Merrew. Green or Spring Frog.
Rana temporaria, L. *Var. sylvatica*, Le C. Wood Frog.
Rana catesbyana, Shaw. Bull Frog.
Rana nigrescens, Ag. Black Frog.

HYLIDÆ.

Chorophilus triseriatus, Willd. Little Tree Frog.
Chorophilus maculatus, Ag. Spotted Tree Frog.
Hyla versicolor, Le C. Common Tree Toad.
Hyla pickeringii, Holb. Pickering's Tree Toad.

BUFONIDÆ.

Bufo lentiginosus, Shaw, *Var. Americanus*, Le C. Common Toad.

URODELA.

PROTEIDÆ.

Menobranchus lateralis, Say. Mud Puppy.

SALIMANDRIDÆ.

Amblystoma opacum, Gray. Blotched Salamander.
Amblystoma punctatum, L. Large Spotted Salamander.
Amblystoma tigrinum, Green. The Great Salamander.
Amblystoma jeffersonianum, Green. Granulated Salamander.
Notophthalums viridescens, Raf. Spotted Triton.
Plethodon erythronotus, Green. Red-backed Salamander.
Plethodon erythronotus. Var. cinereus, Green. Ashy Salamander.
Plethodon glutinosus, Green. Spotted or Viscid Salamander.
Hemidactylum scutatum, Schlegel. Four-toed Salamander.
Spelerpes ruber, Daudin. Red Salmander.
Spelerpes longicaudus, Green. Cave or Long-tailed Salamander.
Spelerpes bilineatus, Green. Stripe-backed Salamander.

SUMMARY.

	Orders.	Familes.	Genera.	Species.	Varieties.
Reptilia	Lacertilia	3	3	4	.....
	Ophidia	2	13	22	6
	Testudinata	5	11	13	.....
Batrachia	Anura	3	4	8	1
	Urodela	2	6	12	1
	5	15	37	59	8

RAISED BEACHES OF LAKE MICHIGAN.

By FRANK LEVERETT.

There are around the head of Lake Michigan several raised beach lines and sea cliffs, the latter being eroded escarpments of the tall plains and moraines. These have been discussed at some length by Dr. Edmund Andrews, of Chicago, President of the Chicago Academy of Sciences, in a pamphlet entitled: "The North American Lakes Considered as Chronometers of Post Glacial Time." The portions of the raised beach lines and sea cliffs in Cook county, Illinois, have been referred to by Mr. Bannister of the Illinois Geological Survey, in his report on the geology of Cook county, Vol. III, p. 240–2. Neither of these gentlemen have given the distribution of the separate lines with sufficient detail to subserve our purpose, and slight inaccuracies of distribution occur in Dr. Andrews' map which accompanies his pamphlet. We, therefore, feel warranted in presenting here the distribution and connections of the beach lines without further reference to previous publications, since our description is based upon those facts only which we have obtained independently.

The beach lines vary in number at different points around the head of the lake, in places there being but one or two — but elsewhere, several, and in Lake county, Indiana, a large number. There seem, however, to be but three lines which are maintained distinctly and vigorously for any great distance. We shall describe these as the Upper, Middle and Lower raised beaches.

UPPER RAISED BEACH.

Between Waukegan and Winnetka, Illinois, the lake shore is now farther west than it was at the time of the formation of the upper raised beach, for the lake is undermining undulating till ridges which show no evidence of having been submerged for any long period. North from Waukegan raised beach lines are developed at intervals, but they have not been studied with sufficient thoroughness to warrant a description. We, therefore, begin our description at Winnetka, in northern Cook county. An ancient sea cliff passes in a southerly course from the lake bluff through the eastern part of this village. The cliff is about twenty feet in height, and is a prominent feature in the village. Its base is very nearly 60 feet above the present level of Lake Michigan.

Following the sea cliff south we find it soon changes to a beach line, and gravel and sand in forms quite similar to those of the present beach lines of

the lake are developed for a distance of six or seven miles through the south part of Tp. 42 N., R. XIII E., and the central part of Tp. 41 N., R. XIII E. The highest part of the beach line, or beach lines, for a series of ridges is developed, is about 60 feet, occasionally 61 feet above Lake Michigan. In the vicinity of the Chicago river, the elevation gradually decreases to the level of the river bank, which is about 40 feet above Lake Michigan. These gravel deposits of the beach line, or of succeeding beach lines which lap onto its eastern face, have an eastward extension on the north side of the river, so that when we cross the river to find the beach line on that side we must go nearly two miles up the stream to catch it. This protrusion of the sands and gravels on the north side of the stream indicates that at the time this beach was forming the transportation of sand and gravel was southward along the shore, and that the current from the Chicago river, which opened into the lake at the point represented by the position of the beach line on the south side of the river, carried the material lakeward which was brought down by the slow moving lake current from the north. This extension is not in the form of a delta built up at the debouchure of the river into the lake — but lies wholly on the north side of the river valley. Moreover, to make it still more evident that it was the lake and not the river which contributed the great bulk of the beach deposit which skirts its north bank, we find that the river valley above the point where it entered the old lake has very little assorted material, such as would accumulate above a delta. The beach appears on the south side of the river in the south part of Sec. 19, Tp. 41, R. XIII E. It has here a very different aspect from that immediately across the river, being a low sea cliff, 6—15 feet in height, with occasional deposits of beach gravels and sands along its front. The terrace or sea cliff made by the lake, is crossed by the Wisconsin division of the Chicago and Northwestern railway, at Norwood Park. The profile of this road shows that the base of the sea cliff has an elevation of 45 feet, and the top an elevation of sixty feet above Lake Michigan.

At the point where the Chicago, Milwaukee & St. Paul railway crosses the cliff, in Sec. 32, Tp. 40, R. XIII E., the base has an elevation of 42 feet and the top 66 feet. The Omaha division of the Chicago & Northwestern railway crosses it at Oak Park, with an elevation of 38 feet at the base and 49 feet at the top of the cliff, and a mile further south the Wisconsin Central railroad crosses a beach deposit with an elevation of 41 feet at the base and 49 feet at the top.

The sea cliff phase extends only to Oak Park, a village on the east bank of the Des Plains river. The sea cliff passes through the east part of the village to the vicinity of the Chicago & Northwestern railway, where beach gravels conceal it, and we find here an extension of the beach gravel down the east side the Des Plains river, similar to that extension down the north side of the Chicago river. The gravel extends south from Oak Park, in the form of a ridge, or bar, 20 to 40 rods in width and 10 feet or more in height, for about two miles to the south part of Secs. 13 and 14, Tp. 39

R. XII E., terminating in a club-like expansion which rises to an elevation of about 55 feet above Lake Michigan, and nearly 20 feet above the plain which lies east of the Des Plains river, immediately south from its terminus. This bar or spit shows evidence, where opened, of having been built up from the east, by successive deposits shingled on its eastern slope — which dip with the slope. An excavation at Haas's gravel pit which extends from the east side of the bar west part of the center — shows beds dipping at various angles, but all toward the east — some of the beds increase in thickness as they descend, but the lower bed, which is mainly sand, increases in thickness toward the deeper portion of the ridge. It appears to be a sand bar upon which the beach deposits were built. The following section was obtained at the south-side of this gravel pit, which shows the section of that particular place only, for I am informed by Mr. Haas that the material of the same bed varies greatly in coarseness within the space of a few feet, but the dip of the beds is uniformly toward the east.

1. A brown-stained gravel at the surface extending down the slope. Depth 18—30 inches.

2. Fine gravel (unstained) 24 inches at top, increasing to 48 inches near base.

3. Sand beginning with scarcely any thickness at the top, but increasing to a thickness of 36 inches at the base of the excavation.

4. A bed of fine gravel increasing like No. "3" from 0—48 inches in thickness.

5. Fine gravel nearly four feet in thickness, which passes upward from near the east side of the excavation assuming a nearly horizontal position beneath the crest of the ridge.

6. Sand at the bottom of the excavation becoming thicker toward the higher part of the ridge. Depth 6—36 inches.

Molluscan shells thought to be Unios, and also smaller shells have been found in No. "6," but none of these were at hand at the time of my visit. Mr. Haas afterwards sent an oyster shell which was imbedded in No. "6," and near it was the tooth of a mammoth. If the oyster shell has not been artificially introduced it suggests much as to a salt water lake. It is possible that the shells thought by Mr. Haas to be Unios, were salt water mollusks. We learned of no other instance of the occurrence of molluscan remains along this upper beach.

Passing now to the west side of the Des Plains river we find about a mile above the southern end of the bar just described a low sea cliff or lake margin bearing in a curved course through Sec. 14, across the north side of Sec. 22, and then northwest into Sec. 16, Tp. 39, R. XII E. This is so low a beach that it scarcely attracts notice, being in places but 2—4 feet in height, but it has the continuity and horizontality of base that marks fossil lake shores.

A tributary of Salt Creek has removed the traces of the old shore west from Sec. 15. The beach comes to the swale which the stream follows.

Passing south about a mile we find the beach well defined in the northwest part of Sec. 28, of this township on the south side of Salt Creek. It is here a beach ridge composed of sand and gravel, and rises 10—12 feet above the border of the plain on the east. The beach line is 30—40 rods wide, and extends nearly one mile south from Salt Creek when the gravel disappears, and a sea cliff marks the continuation of the shore. The bank ridge is excavated about 40 rods from the north end in a similar way to that at Haas's pit; the excavation being from the east side of the beach west nearly to the outer slope. The excavation is 12—14 feet deep in the deepest part, and reveals a series of beds dipping slightly toward the east. The upper 5—6 feet is a brown-stained gravel. The lower portion is a fine gravel with sandy portions almost free from gravel. These sandy portions are not so calcareous as glacial sands. A slight effervescence was obtained in but one or two tests, out of a dozen or more. The gravel is made up of worn pebbles comprising nearly every class found in the drift of the vicinity. There is not such a predominance of limestone pebbles as in the kaves of the neighboring moraines. The nature of the gravel is very similar in Haas's gravel pit to that in the one just described.

A sea cliff passes south from the beach ridge just described, through La Grange. At the point where it is crossed by the C., B. & Q. Ry. its base is 46 and its top 64 feet above Lake Michigan. This cliff continues in a southeasterly course from La Grange to the west border of the Des Plaines river valley, having a height of 10—15 feet throughout the greater part of the course. It swings down the river and becomes a part of its bluff — from a point almost directly west from the village of Summit, near the corners of Secs. 10, 11, 14 and 15, Tp. 38, R. XII E.

Before continuing our discription of the distribution of the upper beach it will be necessary to say a word respecting the outlets of Lake Michigan at that time — since the beach lines are open opposite these outlets. There were two channels of discharge into the Des Plaines valley. The most northerly one had its western border, as stated above, about two miles west of Summit, and its eastern border was about three miles south from Summit, where the river enters the Valparaiso moraine. Between these points the water from the lake entered the channel now occupied by the Des Plaines river.

Another avenue of discharge into this valley was through what is known as "the sag," a low belt of marshy land about one-half mile in width, which passes almost centrally through Tp. 37 N., R. XII E., from east to west, and opens into the Des Plaines valley in Sec. 14, Tp. 37, R. XI E., at Say Bridge Station. Between these two outlets is a prominent portion of the Valparaiso moraine whose base shows evidence on all sides that it was washed by the waters of the lake, the rise from the plain on the east being nearly as abrupt as the bluff of the Des Plaines river on the west or the border of the sag on the south. The sea cliff which was formed around this moraine is flanked occasionally by gravel and sand deposits similar to those found farther north along the sea cliff which was cut in the plain.

South of the sag a sea cliff was formed along the foot of the Valparaiso moraine for about 15 miles southeast from the Des Plaines valley, the sag itself lying near the foot of the moraine for 10 miles or more. The Wabash railroad rises onto the moraine from the sag, whose elevation, as shown by its profile, is but 16 feet above Lake Michigan. The gravel flanking the high land each side of the sag indicates that a depth of 40—50 feet of water passed througn it at the time of the formation of the upper beach lines.

The plain in Tp. 36 N., R. XIII E., which lies between the sag and the moraine, rises toward the moraine quite rapidly, its border next the moraine being 50 feet above Lake Michigan at the point where the C., R. I. and P. Ry. passes from the plain to the moraine. The sea cliff here rises 28 feet above the plain or 78 feet above Lake Michigan. It is not probable, however, that the water stood as high as the top of the cliff. There is evidence along the border of the moraine, a short distance east, that it was some five feet or more in depth — for sand and gravel deposits flank the moraine to about this elevation above the level of the plain.

In the northwest part of Sec. 25, Tp. 36 N., R. XIII E., a beach line leaves the border of the moraine, and from this point southeast to the state line near Dyer, Indiana, it lies one to two miles north. The Illinois Central railroad crosses it about one mile north of Homewood. The top of the ridge is 65 feet above Lake Michigan (as shown in the profile of this railroad). The beach deposits cover a width of nearly a mile where crossed by this railroad, and their north border is but 41 feet above Lake Michigan. The highest portion of the ridge is mainly sand, and evidently was drifted by the wind so that its crest is now several feet above the water level at the time of the formation of the beach.

At the crossing of the Chicago and Eastern Illinois Railroad near Glenwood, the crest of the ridge is 55 feet above Lake Michigan. The ridge maintains about the same elevation to Dyer, Indiana. A sea cliff flanked by beach gravels is developed near the state line.

Before taking up the description of this beach in Indiana we will note the effect produced by the lake upon "Blue island," a till ridge running north from Blue Island village, some five or six miles. It is evident that this till ridge was an island in the old lake, for its border is very abrupt like a sea cliff and its surface is billowy. Furthermore flanking nearly the whole of the western face — there are beach deposits — whose base is 35 — 45 feet above Lake Michigan. Toward the north end of the ridge the sand has drifted into dunes, a few of which attain an elevation of 80 feet above Lake Michigan, but the beach gravels were nowhere observed to have an elevation to exceed 55 feet above the lake. From the north end of the ridge a bar composed of both sand and gravel extends out across the plain in a W. S. W. direction for more than a mile. The plain is about 45 feet above Lake Michigan, and the bar rises in plains to an elevation of 15 feet above this plain. This was evidently formed in the lee of the ridge and is

an indication that the waters flowed west past the north end of Blue island, at the time when the bar was formed.

The upper beach in Indiana presents a very different aspect except at the immediate border of the two states from what it has in Illinois, for it is composed mainly of sand, and the sand has drifted into prominent dunes and ridges which have frequently an elevation of 25 feet or more above the plains which lie south of them, and still higher above those on their north face. The elevation of the plains which lie immediately south of the sand ridges seldom exceeds 60 feet above Lake Michigan. It is evident, therefore, that the level of the lake was not more than 60 feet at the time of the formation of this beach, though its dunes have sometimes an elevation of 80 feet above Lake Michigan.

From Dyer, a sea cliff flanked by beach gravels passes nearly due east, changing within two miles to a ridge of dunes. This ridge of dunes passes through Schereville and extends east of this village about two miles when it quite suddenly terminates on a till plain in the east part of Sec. 12, Tp. 35 north, range IX, west. The sand here apparently has drifted in a continuous ridge a mile or more beyond the old lake border, for passing northwest to the vicinity of Griffith, a distance of a mile or more, we find the lake border marked by another line of dunes or rather a belt comprising several more or less continuous lines of dunes trending W. S. W., E. N. E. in the same direction as the course of the Joliet division of the Michigan Central railroad from Griffith to Lake — and thence along the main line of the Michigan Central railroad for about five miles farther east. The belt is 1 and 1½ miles in width and lies almost entirely on the south side of these railroad lines. Near Liverpool this belt is joined by the line of dunes which represents the middle raised beach, and from this village eastward the two branches are closely associated. Near the crossing of the Baltimore and Ohio and Michigan Central railroads, a sudden deflection in the direction of the dune ridges occurs. The whole belt comprising here four main ridges and several smaller ones suddenly swerves from an E. N. E. to a nearly due north course — and passes north to the Calumet marsh, at the border of which all the ridges suddenly terminate. North of this marsh the lower beach ridges, or at least ridges which are quite continuous with those farther west that are evidently later than the upper and middle beaches, occupy the interval between the present beach of the lake and the till tracts which lie south of the system of raised beaches. We consequently find no indications on the north side of Calumet river, nor indeed in the portion of Indiana east from there that these beaches remain, for the sands of the lower beach conceal everything. In Michigan, however, we find traces of the earlier beaches, some of which have been mentioned in the preceding chapter. The till ridge which lies east of New Buffalo, has gravel in indistinct ridges at intervals on its western slope — the highest observed deposits being about 60 feet above Lake Michigan.

North of Galvin river in Secs. 36 and 25, Tp. 7 S. R. XXI W., is a beach

line running from the bluffs of the Galvin river valley, north to the lake bluff. Its elevation at the lake bluff is about 55 feet, by aneroid determination, above the present lake level. This probably represents the Upper beach.

At several points between these "clay banks" in Sec. 30, Tp. 7 S., R. XX W., and Sawyer in Sec. 2, of the same township, the gravels on the river slope of the till ridge, which passes from the clay banks northward are in the forms of beach lines. They occur at an elevation as great as the track of the Chicago and Western Michigan railroad, which is 55–60 feet at several points where comparisons could be made. One of the best developed fragments of a beach line may be seen 100 rods or more west of the depot at Sawyer, where it is crossed by a wagon road. No beach lines were observed north from Sawyer, which will be included with the Upper beach deposits, but occasionally the slopes of till ridges were coated slightly by gravel at elevations about the same as those of the Upper beach — *i. e.*, — 55 feet or more above Lake Michigan.

The lake bluffs north from St. Joseph were examined with reference to finding the elevation to which the gravels occur, both in eroded dunes and above till bluffs, but nowhere were any deposits found at a height exceeding 35 feet above the lake. Quite frequently eroded dunes exposed gravel to an elevation of 20—35 feet, but this is probably to be classed with the gravels of the middle and lower beaches.

THE MIDDLE BEACH.

We find it necessary to explain the general surface features of a tract north of the Chicago river before attempting to give the distribution of the beach lines which border it. There is a till plain lying east of the portion of the upper beach that lies north of this river. Its western border is 30 feet or more above the level of Lake Michigan. This till plain has a width of two to four miles, and descends toward the east to an elevation of but 10—15 feet above the lake. East of this till plain there is a prominent beach line rising to an elevation of 30—35 feet above Lake Michigan. The plain therefore appears to be bordered by two beach lines, the one on the west being 40 feet more or less above the level of the lake, while that on the east is 30–35 feet. Taking up now the distribution of these beach lines we can best describe the western one as lying along the eastern face of the portion of the upper beach north of Chicago river, differing from it only in elevation, and in having a more easterly extension down the north side of Chicago river. The eastern beach line leaves the lake bluff about two miles north of Evanston and passes nearly due south for some seven miles to Rose Hill cemetery. At the cemetery it makes an abrupt turn to a course slightly south of west and extends to Bowmanville in Sec. 12, Tp. 40 N., R. XIII E., where it drops down quite suddenly near the bank of the Chicago river. It does not reappear on the opposite side of the river. The interval between the eastern end of this ridge and the western terminus of the spur-

like prolongation of the western beach line down the north side of the river is fully 1½ miles. This inward curving of the southern ends of the two beach lines diminishes the distance between the ridges one-half, but still leaves so wide a gap that the connection of the eastern ridge with the series of raised beaches is not yet satisfactorily determined.

No good exposure was found in the western beach line, but the eastern has a diagonal exposure of its whole vertical section at the lake bluff. Portions of the plain which lies immediately west of this ridge are covered with peat, and we find that at the exposure along the lake a peat bed which lies near the surface just west of the ridge, passes under the ridge as shown in the following section and description.

Section near beach line beneath plain which borders it on the west:

1.	Soil and gray sand	12–15 inches
2.	Peat	2– 3 inches
3.	Gravelly sand	6–36 inches
4.	Yellow pebbly clay, very calcareous	11–12 feet

The clay No. "4" assumes a bluish cast near the bottom, just above the water's edge. Its upper surface is eroded, and No. "3" has filled up the old channels or irregularities in its surface. It is for this reason that it varies so much in depth. No "3" contains blocks of limestone 8–10 inches in diameter, but the majority of its pebbles are small.

As we go from this exposure through the exposed section of the beach, we find the sand which overlies the peat bed in the above section, increases in thickness as soon as the ridge is entered. When it attains a thickness of about five feet, a coarse gravel and cobble appears above the sand. This cobble-gravel is a thin bed at first, but increases to a thickness of 11—12 feet beneath the highest part of the beach ridge, and has here layers of sand interstratified with it. The bed of sand which lies beneath this gravel has a depth of some ten feet or more beneath the deepest portion of the ridge. It is underlain by a peat bed, the continuation of the peat which lies near the surface west of the ridge, as is shown in the above section. The peat bed has slight breaks in it beneath the beach ridge, but can be easily followed at a quite definite horizon entirely through it. It is 3—6 inches in thickness. It contains pieces of mangled wood beneath the higher portions of the ridge. Between this peat bed and the yellowish blue till which forms the base of the exposure, there is a gravelly sand 6—18 inches in depth. The till rises about 12 feet above the level of the lake. The elevation of the crest of the beach ridge is about 35 feet above Lake Michigan.

The peat bed is found along the lake shore east of this beach, near the surface, as it is west of the beach. The beach appears, therefore, to have been built upon a submerged land surface. There is probably significance in the fact that the peat only extends a few rods west from the beach ridge, but fringes it on this border for several miles. East of the beach the peat occupies a considerable portion of the interval between this and a

Lower beach which is described later, and it was observed beneath this lower ridge in the same situation as beneath the ridge just described. The writer has not been able thus far to satisfy his own mind with any theory explaining the burying of this peaty surface beneath these lake beaches If the beaches were composed entirely of sand, their material might have been drifted beyond the lake border and covered the adjacent lands, but there is here a heavy deposit of coarse gravel capping the beach, which certainly could not be drifted by the wind. It might seem easy to account for the phenomena by supposing that there have been oscillations of level with periods of emergence followed by periods of submergence, but we found no evidences of such oscillations elsewhere. The limitation of the peat to the immediate border of the beach also presents difficulties in forming an explanation under hypotheses which have thus far arisen. The writer has attempted to conceive a method by which a protective bar could have been built up into the form which this beach line presents, but has not been successful.

Continuing now the distribution and description of the Middle beach from the Chicago river southward, we find that the western Middle beach repeats the phenomena of the Upper beach in swinging down the north side of the Chicago river so that when we cross the river to find its continuation we must pass up stream some two miles. The Middle beach is well developed immediately north of Jefferson, in Sec. 9, Tp. 40, R. XIII E. It has here an elevation of 40 feet above Lake Michigan, and is therefore as elevated as the portion of the beach immediately opposite, and some 5—10 feet higher than the spur referred to above as extending eastward along the north side of the river.

This beach line has a course varying slightly to the east and west of south through Cragin's and Austin to the south part of Secs. 16 and 17, Tp. 39, R. XIII E., when it assumes a southeasterly course to the Des Plaines river, at Riverside. The following are the elevations of the crest of this beach at points crossed by railway lines: Jefferson, 40 feet; Cragin's, 38 feet; Austin, 38 feet; Wisconsin Central crossing (west side of Sec. 16, Tp. 39, R. XIII E.) 38 feet; Riverside, 40 feet.

This portion of the beach line between the Chicago and Des Plaines rivers seldom rises more than 6—7 feet above the plain, which borders it on the east, and but 2—3 feet above that on the west. It is a low beach, coated by beach gravels 1—2 feet in depth, with an occasional depth of 6—8 feet. This bench is a noticeable feature on the level plain, though its elevation is so slight, and its course is well shown by a narrow belt of timber, which follows it across the otherwise treeless prairie.

Between Riverside and Summit is the old outlet of Lake Michigan into the Des Plaines valley. At Summit there is a prominent beach line turning down the east bluff of the Des Plaines river, which traced eastward from this opening into the river valley, takes a more or less direct course toward the north end "Blue island till ridge," and keeping slightly north

of this till ridge, it swings around to its eastern side, and bearing away from its southern end, comes to the Calumet river near Riverdale. Its elevation at Summit is 40 feet; at Washington Heights, 41 feet; but at several points between these villages a survey made by the Chicago Drainage Commission, reports its elevation as 35 feet above Lake Michigan.

The best exposure of the structure of this portion of the beach is found at Summit. An extensive excavation is made near the curving portion of the beach, just as it is about to turn down the River Valley. The beds of gravel dip toward the north with a low angle (10—15°). There is but little sand with the gravel. For a short distance the excavation shows a depth of 20 feet of beach deposits, but in passing eastward the pebbly clay which underlies them rises perceptibly. The gravel is brown, stained to a depth of 3—4 feet from the surface. Below this depth it is unstained. It is but slightly calcareous, even in the finer sandy portions. The pebbles seldom exceed one inch in diameter. They are worn smooth like those along the present beach of the lake.

We are told that shells of Unios and of smaller mollusks, also fragments of wood, have been found at the base of the gravels, but none were at hand at the time of our visit. Portions of the beach east of Blue Island are quite sandy.

South from the Calumet river this beach has a wide break, for the lake discharged past the south end of Blue Island through the sag into the Des Plaines river valley. The outlet from Blue Island, west to the point where the sag narrows to pass through the Valparaiso moraine, has a width of no less than three miles. Its north border is well marked in the form of a sea cliff, on the north side of the sag, and on the south it washed the foot of the Valparaiso moraine. An island locally known as Lane's Island, lies in this outlet, and its borders are flanked by gravelly deposits, to an elevation of about 35 feet above Lake Michigan. This island apparently, was submerged at the time when the upper beach was formed, for its surface is very level and has a coating of sand. Similarly, a large tract of land west of Blue Island, which was not submerged at the time of the formation of the Middle beach, was covered by the lake at the epoch of the Upper beach.

We were interested in noting a boulder-strewn belt occupying the portion of the sag outlet, just east of the Valparaiso moraine. The boulders in places, number several thousand per acre, so that it is very difficult to till the soil. They are both Paleozoic and Archaen. They may, many of them, have been dropped by ice-floes at the time of the lake expansion, for the configuration of the channel west from here, is such as to impede a free discharge into the Des Plaines valley, but a portion of them probably, were dropped there by the glacier, at a much earlier period, for other gaps in the moraines, similar to the sag, where the lake had no outlet, often have a large number of bolders in them.

The lake at the epoch of the Middle beach, probably extended nearly as far

south as at the time of the Upper beach, for no beach lines were observed west of the Illinois Central railroad. East from this railway, however, a well-defined beach exists. It assumes sufficient prominence to be noticeable in Secs. 27 and 28, Tp. 36, R. XIV E., there being on these sections a low beach 10—15 feet high, a portion of which is a rocky escarpment, but the remainder is till across Thorn Creek, from the east end of this bench in Sec. 35 of the same township, a beach line of much strength is developed. It is 40—80 rods wide, and has dunes 20 feet or more in heighth. It has a nearly due east course for three miles in Illinois, passing through the village of Lansing. It continues into Indiana with the same course, lying along the north border of Cady marsh, to the eastern end of the marsh, thence it continues with a cousre slightly north of east to Liverpool, where it becomes associated with the Upper beach lines, and its further distribution is given in connection with those beaches. The Indiana portion of this beach west of its junction with the Upper beaches, is a single ridge of sand slightly pebbly in places. It drifts into dunes at several points, but none were observed whose height exceeds 40 feet above the plain at the base of the ridge. The ridge where not drifted into dunes, is some 15 feet above its immediate base, and has a width of 40 rods more or less. Its elevation at Lansing, Illinois, is 43 feet above Lake Michigan. No other elevations are at hand at time of writing.

Between this beach line and the Calumet river there is a plain underlain by pebbly clay, and having scarcely any coating of sand or gravel. The beach deposits seldom extend more than 80 rods north from the base of the ridge.

THE LOWER BEACH.

The most northerly point at which this beach has been identified is at Evanston, Illinois. It rises here nearly 25 feet above the lake, and has at its northern extremity a width of 30 rods or more. It passes through the eastern part of the city of Evanston, and its course from Evanston to Ravenswood is nearly south. From Ravenswood it bears slightly east of south, to Lincoln Park in the north part of Chicago, and passes through the western part of this park. In the early days of Chicago, the ridge was developed at intervals through the eastern part of the city, but all traces are now removed. In the southeast part of Chicago, and in Hyde Park, the beach has not been removed. Between Hyde Park and Englewood it is well developed, having an extreme elevation of 19 feet above the lake. From Englewood it passes south through Sec. 21, to the center of Sec. 28, Tp. 38 N., R. XIV E. South from here it is a low belt of land ½—¾ mile in width, and rising scarcely 10 feet above Lake Michigan, which connects the low lands west of Chicago, and in the Stock Yards in the southwest part of Chicago, with the low land along Lake Michigan, near Lake Calumet.

South from this low belt there are two beaches, neither of which are the exact equivalents in height of the ridge we have just traced. The innermost of these beaches extends from the head of Lake Calumet, east of Pulman, northwest to the vicinity of South Lynn. In is a bench 4—6 feet

in height, capped by a slight deposit of beach gravels. Its elevation is but 12 feet above Lake Michigan, for two miles or more from Lake Calumet, but further west it is 15—20 feet. Low as it is, it marks a quite distinct change in the surface deposit. On its east side is a sand deposit, 1–18 feet in depth, but on the west there is a pebbly clay, except along beach lines already described.

A second beach lies about a mile west from the one just described. It is a bench or low sea cliff 10–12 feet in height along its southern part, but less in the northern part. It can be traced easily from the Calumet river, near Riverdale, north through Kensington, to the northwest corner of Sec. 15, Tp. 37 N., R. XIV W., where it merges into the plain which borders it. South of the Calumet river, in Riverdale, is a ridge of sand and gravel which is probably of the same age as the bench at Kensington. It has a course almost due southeast to the Indiana line, entering that state about 1¼ miles south of Hammond.

An interesting problem arises as to the outlet of Lake Michigan at the time the lower beach was forming. There may have been a narrow outlet through the Calumet, from Riverdale to Blue Island, and thence through "the sag," into the Des Plaines valley. There may have been another from near Lake Calumet, just between the Englewood beach and the low benches above described, into the Chicago river near the Union Stock Yards, and thence west through a marshy tract called "Mud Lake," to the Des Plaines river. There may also have been an outlet via the Chicago river, through the city to "Mud Lake," and thence into the Des Plaines valley. There are no points along any of these low belts that exceed 16 feet above the present level of the lake, and those via. "Mud Lake" are in no case above 10 feet. Probably the whole region in and near Chicago, whose elevation is 15 feet or less above Lake Michigan, was covered with water at the time when this beach was forming. It is also probable that the outlet at the north end of Lake Michigan was opened during the period when the lower beach was forming, if it had not opened previous to that time.

We are indebted to Prof. Oliver Marcy, of Evanston, for a careful section of the beach at the lakeshore in Evanston, made in 1864, at which time there was a peculiarly good exposure. The section was exposed north of Heck Hall, at the border of the University campus:

1.	Surface soil, sandy	1½ feet
2.	Brown sand and fine gravel	2½ feet
3.	Coarser gravel, stratified	2½ feet
4.	Fine sand	2 feet
5.	Gravel containing bones of deer	1⅛ feet
6.	Fine sand containing oak logs	1½ feet
7.	Peat or carbanaceous earth, with a marl bed containing molluscan shells in the lower portion, or interstratified with the peat	1½ feet
8.	Gravel	3¼ feet
9.	Humus soil with cedar stump and logs	4–6 inches
10.	Yellow clay laminated and contorted—containing pockets of gravel	3½ feet
11.	Blue pebbly clay	2 feet
	Height of bluff	22 feet

Prof. Marcy has representatives of the above beds in their natural order, in a glass cylinder. He also has the organic remains referred to. The bone is a portion of the femur of a deer—(species not determined). The oak wood is well preserved but the cedar is mangled and slivered. Prof. Marcy also has specimens of mollusks collected from the marl beds associated with the peat in No. "7" of the above section. The following are specifically identified—1. Planorbis campanulatus. 2. Planorbis pava. 3. Amnicola hinosa. 4. Pisidium dubium. 5. Cyclas sulrata.

Unios of various sizes occur, which are not specifically identfied. There are also other molluscan remains not included in the above species.

Mr. H. M. Bannister of the Illinois Geological Survey, mentions the fossils found in these beach lines in Vol. III, p. 242, of the Illinois Geological Reports. He states that there are found existing, species of Unio, Pisidium, Physa, Lymna, Planorbis, Volvata, Amnicola, Milantho and Ancylus.

A partial exposure at the point on the shore represented by Prof. Marcy's section abave given, was examined by the writer in 1887, and the following section obtained:

1.	Yellowish red (iron-stained) sand	3-5 feet
2.	Band of bog iron ore granular	4-6 inches
3.	Gravel with beds of sand included	5-7 feet
	The stratification is very irregular in thickness and assorting very imperfect)—	
4.	Coarse sand not calcareous	6-12 inches
5.	Calcareous loam	3 inches
6.	Yellow clay very calcareous with leaves embedded	3 inches
7.	Carbonaceous band not calcareous	2 inches
8.	Yellow calcareous clay similar to No. "6"	4-6 inches
9.	Band of carbonaceous material not calcareous	2 inches
10.	Brown sand with twigs and peaty material	8-10 inches
11.	Water bearing sand	

Talus obscures the lower portion of the bluff. Nos. "6" and "8" contain gasteropod shells.

Several exposures of Nos. "6—9" were noted along the lake bluff further north. They were found well developed at outcrops beyond, i. e., further northwest than the outcrops of beach deposits, which overlie them in the above section. Beneath them is a yellowish sand four feet or more in depth, and beneath the sand resting upon a pebbly clay is an occasional outcrop of humus soil, probably No. "9" of Prof. Marcy's section.

In a cut where the wagon road comes down to the lake shore, south of the Evanston waterworks, the peat beds pass back into the peaty soils of the low land west of this beach ridge. The connection of this peaty bed with that beneath the eastern ridge of the middle beach, has already been discussed in connection with that ridge.

The profile of Fullerton Avenue conduit in the north part of Chicago shows the depth of sand and gravel through the entire width of the deposit between the lake shore and Chicago river. The ridge portion of the lower

beach lies 1,400—2,100 feet from the lake shore, and the maximum depth of sand (25 feet), is about 1,700 feet from the lake. On the west border from 2,100—2,600 feet, the depth is about 17 feet, and from 2,600—6,000 feet it averages about 12 feet in depth. From the latter point westward the depth gradually decreases and the sand disappears 1,900 feet east from the Chicago river. From the inner border of the beach ridge, to the lake shore a distance of 1,400 feet, the deposits are about 18 feet in depth. At the water's edge the depth is but 10 feet. The profile continues out 1,100 feet beneath the lake and there is but three feet of sand and gravel at its terminus. The deposit throughout is mainly sand, but some gravel was encountered. Shells of Unios and other mollusks were imbedded at frequent intervals throughout nearly the whole width of the deposit. Beneath these beach deposits there is everywhere a pebbly blue-gray clay, and no difference could be detected in emerged and submerged portions. This pebbly clay is described in a previous chapter.

In Hyde Park, the lower beach contains much more gravel than is shown in the Fullerton Avenue profile. The width of the system of raised beaches between Hyde Park and Englewood, is fully one mile, and between these beaches and the present beach, the surface is covered with sand and gravel.

At Riverdale the beach deposits are scarcely four feet in depth, but at Dolton Junction they are eight feet and two miles east of Dolton, the depth along the west of the ridge is 12—15 feet, and at the state line it is reported to be about 24 feet. The whole surface from Lake Calumet south to the beach ridge just alluded to, is covered with sand, the depth of which in places is at least 18 feet. The whole interval in fact between the lower raised beach and the present lake shore is covered with sand, not only in Illinois, but also in Indiana and Michigan, as will appear on a subsequent page. Its separation from the present beach is merely a matter of elevation, apparently, consequent upon the gradual lowering of the level of the lake.

The beach which enters Indiana about 1½ miles south of Hammond, passes east through the villages of Hessville, Tolbston and Miller, lying 1—2 miles north of the Little Calumet, and about an equal distance south of the Grand Calumet river. East from Miller the beach is quite continuous as far as Michigan City, lying 1—2½ miles back from the present beach. East from Michigan City there are only fragmentary beach lines, the distribution of which will be given presently.

Between the beach just described and the present beach, there are in Lake County, Indiana, a series of lower beach lines separated by narrow swamps, which fill the whole interval between the lake and the beach, leaving no such broad level tracts as occur between the Middle and Lower beaches along the Little Calumet and between the Upper and Middle beaches along Caeby marsh. On the meridian of Hessville, there are not fewer than thirty of these lower beach lines. These beaches are more closely associated with the main Lower beach in Porter county, for the

interval between this beach and the lake is much narrower than in Lake county. These minor beach lines are but a few feet in height, and 6—10 rods in width. At their western ends they are lost in the sandy plain which borders Wolf Lake, Lake Calumet and other small lakes near the state line or the borders of Lake Michigan. It is probable that these beach lines have each in turn shut off portions of the lake lagoons, and thus made encroachments upon it. They were probably built up as bars, working their way westward along the coast, for the shore currents at the present day are carrying sand across the south end of the lake in a westerly course, and building up broad branches at the head of the lake.

By reference to the Illinois beach lines it will be seen that from Chicago south, the beach which formerly bore west of south to Englewood, has by gradual accretions along its eastern border, been built out several miles to the eastward. The shore currents on the west side of the lake are southward, and consequently they unite with the westerly currents on the south shore to build up a broad beach at the head of the lake; near the state line between Illinois and Indiana. Between the western ends of the low beaches in Lake county, Indiana, and the southern ends of the beach lines near Englewood, in Illinois, is a low sand-covered tract occupied by several small lakes, and nowhere rising to the height of the beach lines, much of it being scarcely five feet above the level of Lake Michigan. This was apparently an open bay at the time these bar-like beaches were forming, but has now become filled with sand, leaving Lake Calumet and other lakelets and ponds as remnants of its waters.

The shores of the lake at the present day are not stationary. In one place encroachments are made upon the bordering shores while in adjacent portions of the shore accretions and accumulation is going on. Thus from Waukegan to Evanston, Illinois, the bluffs are undermined and removed at a rapid rate, but from Evanston, south to the head of the lake, the accumulation along the beach is greater than the removal. On the opposite side of the lake from Langatuck, Michigan, to a point on the shore some ten miles southwest from Michigan City, Indiana, the removal is greater than the accumulation, but as is shown above, the accumulation exceeds the removal along the remainder of the south shore. The projecting points along the lake are undermined more rapidly than the heights, so that the lake tends toward a more regular outline by its erosive power, and as we have seen above the bay-like elongation at the head of the lake has been greatly reduced since the epoch of the main lower beach, so that the lake is also tending toward a smoother outline by its depositing power.

The lower beach in Indiana is composed mainly of sand — gravel being found only in its deeper portions. The sand has drifted into dunes throughout the entire length of the beach lines in this state — so that elevations taken along the crest of the main ridge do not show the height at which the lake stood during its formation. By aneroid determinations there is a range of more than 50 feet in the elevation of this crest, some portions be-

ing 80 feet or more, while other portions are but 30 feet above Lake Michigan. The depth of sand at the powder works near Miller, is 32 feet. Beneath the sand is gravel and sand in which are shells of mollusks called snail shells by the well-digger, who reported them. The elevation of the surface is probably not more than 50 feet above Lake Michigan.

Gravel has been encountered near the bottom of wells along the ridge in several instances; the writer has no means of computing accurately the elevation above Lake Michigan, but it is certainly not more than 20 feet. The Lower beach in Michigan occurs at intervals only. It consists of dunes and low sandy ridges lying back of the dunes of the present beach, which form a bold front along much of the Michigan shore. They are usually separated from these higher dunes by marshy belts, but sometimes lie immediately back of them. Their height seldom exceeds 40 feet, while the dunes along the shore are in some cases 125 feet or more in height.

The most southerly development of these older ridges in Michigan is found on the east side of the Michigan Central railroad in New Buffalo township, where they extend for more than a mile along the railroad. North from here no ridges of this epoch were noticed south of the clay banks, in Tp. 7 S., R. XXIV, but north from there to the vicinity of St. Joseph, dunes were noted at frequent intervals lying east of the belt along the shore. A similar distribution of two series of dunes was noted west of Carrot, in Van Buren county. Further north this Lower beach was not thus identified. Occasionally gravel deposits are exposed along the lake shore, capping the till at elevations of 10—20 feet, which may represent this epoch, but quite as frequently these deposits, as has been already noted, rise to heights corresponding with the elevation of the Middle beach (30—35 feet above Lake Michigan). The main development of the raised beaches, not only of this epoch, but of all epochs, is found in Illinois and Indiana, for it is only around the head of the lake that the land has gained more than it has lost since the epoch of the first (Upper) beach.

ON THE EMPLOYMENT OF THE METHOD OF LEAST SQUARES IN THE REDUCTION OF TRANSIT OBSERVATIONS.

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In longitude work upon the continent of Europe the polar stars employed to find the azimuth and collination of the transit are usually within a few degrees of the north pole. Each such star gives a value of the azimuth, and three are generally observed each evening, in reversed positions of the instrument; while the time-stars are, according to the instructions, twenty or more in number, arranged symmetrically about the polars, in such manner as to give opportunity for two exchanges of signals. The declinations of these time-stars are arranged at the same zenith distances south, as the polars are north of the zenith, so as to eliminate pivot-errors.

This arrangement, for latitudes near 50°, combines the following advantages:

1. The polar stars are slow enough in their apparent motions for a deliberate reversal during each of their transits.

2. The time-stars are in the declinations most favorable to accurate observation when they are equally distant from the zenith with the polars.

3. The reduction becomes extremely simple in execution, as the different instrumental corrections are directly determined and equations of conditions, to be solved by the method of least squares are not required.

For the more southern latitudes of Europe, which correspond to those of the northern part of the United States, these three conditions cannot be simultaneously fulfilled. If, for instance, the second condition be insisted upon, the first falls out, for latitude 43°, and *vice versa*. In order to fulfill this second condition the average declination of time stars must be taken at about 20°; and the polar-stars at 66°: which is too far south to accomplish the necessary reversals without hurry during the single transits.

Certain limitations, however, which are necessary in Europe, are needless in America. For instance, the greater length of the circuits over which very much of our telegraphic longitude work is done, renders it very difficult to observe the same stars at both stations. As our absolutely definitive reductions are not immediately necessary, the star-places used in any campaign can be left open for future improvement; when, for instance, geodetic measures shall be made over the whole territory. Again, the unsettled country in which much of the work is done renders it necessary for us to

adopt a different type of instruments from the European, lighter and more portable, less liable to injury in transportation; but, on the other hand, more care has to be exercised in so arranging our star-lists that all conceivable instrumental errors shall be eliminated; we cannot depend too fully upon one particular arc of the circle described by the telescope. All these things considered, it has been the practice of American observers to select their time and polar stars in a much wider range of declination than the Europeans employ; and to use the method of least squares in their reductions.

I have myself employed these methods, both of selection of stars and reduction, in second longitude campaigns; and have formulated for myself the practical rules to be followed. The earlier years of this work were spent in determinations at very distant points, accessible with difficulty, and with quite inferior instruments; so that, as they were also usually in bad repair, it required very careful handling to produce even tolerable results.

Later, in 1878, I had the use of an excellent transit instrument, which was in first-rate condition; and was then able to apply the rules which I had previously made for myself, to a better state of external circumstances. In the present paper I shall state the conditions for a good series of time-determinations in this country, as I now understand them, with especial reference to the western States and Territories, and the methods of reduction.

The observations to which I have last referred were made in 1878, at Ogden, Utah, in latitude 41° 13′. The results are given in the Report of the Chief of Engineers for 1879–80 (Executive Documents, 2d Session, 46th Congress, Vol. 5), pages 1989–5. It will be seen that during a space of 2½ months, from July 25th to October 10th, 74 days in all, there were 67 determinations of time. Signals were exchanged on 26 nights with the regular observers of Captain Wheeler's survey; and the observations on these nights reduced by the method of least squares; all these calculations, as well as the preliminary ones necessary for the other nights, were completed within the two months after the first exchange, August 12th, so that the method of reduction is not too complicated to be practicable.

The following would be, in my judgment, an advantageous selections of stars for a latitude 41° — 44°; the group is arranged nearly as at Ogden, and differs from my ordinary arrangements in those times only because I had then fewer close polar stars available. The stars are taken from the Berlin Jahrbuch, or other ephemerides, and from my catalogue of 2018 stars published by the Engineer Bureau:

Name of Star.	A. R. 1885.0	Decl. 1885.0	Remarks.
κ Cassiopeiæ	0 26 28	+ 62 18	
π Andromedæ.....	0 30 44	+ 33 5	
55 Piscium	0 33 52	+ 20 48	
o Cassiopeiæ	0 38 19	+ 47 39	
δ Piscium	0 22 43	+ 6 57	
Cephei 43 H.....	0 53 12	+ 85 38	Reverse on this star.
ε Piscium	1 2 27	+ 5 2	
τ Piscium	1 5 20	+ 29 29	
α Piscium	1 7 30	+ 23 59	
f Piscium.....	1 11 52	+ 3 1	
ψ Cassiopeiæ	1 17 41	+ 67 31	

It will be noticed that I have introduced no stars at lower culmination. The reason for this is, that unless they are very near the pole, the azimuth co efficient which they furnish is positive in sign, and the stars which balance them as to the sign of this co-efficient do not as to the form of the pivots. In other words, a combination of stars below and above pole would give the clock correction with a large probable error and with a danger of constant error, while a combination of stars below pole with those at corresponding south zenith distances would be far less advantageous, owing to the identity of sign in the azimuth co-efficient, and its greater magnitude for the southern stars, than a combination of stars above pole on the north side with the ordinary northern time-stars.

When the least square reduction is made, the theoretical test of a good combination is obtained by Jacobi's theorem, which I quote below; the practical test by the quotient.

$$\frac{\text{Weight of clock-correction.}}{\text{Number of transits}}$$

which should approach the weight of one transit of a zenith star: Practically I usually employ the following formula for the weight or of one complete transit (on 5 or more wires, or 7 or more, according to the way the diaphragm is arranged).

$$w = \frac{1.3}{1 + 0.3 \text{ Sec.}^2\delta}$$

For latitude 42° 42′ 5, this gives the weight of a zenith star equal to 0.836; in general it is easy so to arrange the groups that the weight of the clock correction from 10 stars shall be 7 at least; but where lower culminations and southern stars are freely employed this number frequently is reduced to 5 or less. That is to say, 10 stars well arranged give as good a clock correction as 14 ill arranged; and waste of time spent in computation is thus avoided. The few extra minutes lost in observations are usually of less account; and are perhaps compensated by the greater pains necessary beforehand. In order to modify the weight-formula to advantage more

observations are needed, which I intend to make with a portable instrument now constructing for Williams College Observatory; the field observations have confirmed it with sufficient certainty for my purposes. For in my least square reductions I have pursued the course so strongly recommended by Gauss (Astr. Nachrichten v. 5, cols. 227 following; Méthode des moindres carrés, mémoires traduits par J. Bertrand, p. 163) of determining in advance approximate values of the unknowns, and using the least squares only to find minute corrections. And the following are the results for the clock-corrections of the dates in the Ogden campaign, as published in the Report before alluded to:

Date.	Correction to provisional result.	Date.	Correction to provisional result.
	s.		s.
Aug. 12.....	−0.008	Sept. 20.....	+0.001
19.....	−0.021	21.....	−0.020
21.....	−0.003	22.....	+0.001
26.....	−0.010	26.....	+0.001
28.....	−0.006	27.....	−0.008
Sept. 5.....	+0.016	30.....	+0.011
7.....	+0.010	Oct. 1.....	−0.002
8.....	0.000	3.....	−0.009
10.....	−0.010	5.....	−0.005
11.....	+0.017	6.....	−0.005
12.....	+0.009	7.....	−0.003
13.....	+0.010	8.....	−0.013
17.....	−0.031	10.....	−0.007

The total effect upon the longitudes of the application of least squares, consists in the differences of their corrections for the stations. The observors at the corresponding stations in this campaign had worse instruments than I, and were not so scrupulous in arranging their star lists; so that the corresponding corrections came out rather larger. Their time determinations did not suffer sensibly from this cause, however; as both were experienced observers. The average without regard to sign of the 26 numbers given above — each of which, with trifling exceptions is the result of two groups of stars — is $0.^s 0091$: and the probable error of one preliminary solution $\pm 0.^s 0077$; or for a single group of 10 stars $\pm 0.^s 011$.

It is evident, then, that if the weights are assigned by my formula with approximate corrections — so, for instance as to make sufficient distinction between a very slow-moving and a quiet-moving star — there need be no fear that it is not correct enough. The objections to the old process of giving all stars a weight unity is that the polars of high declination dominate too much in azimuth; this process is about equivalent to leaving out the quicker-moving stars north of 65° altogether.

Another practice which is quite common is altogether meaningless. When the weights are approximately correct there is no necessity of omit-

ting the polar stars in arranging the final table of clock corrections. Each star, quick-or slow-moving, should go in, with its proper weight to the clock-correction The method of least squares gives, namely: the *most probable* values of all the unknowns; and a *more probable* one than this cannot be obtained in any other way, unless the original system of weights be altered. But this would involve a contradiction; the weight, according to definition, refers not to the use to be made of the observation, but to the measure of its precision. The following example taken from my work on the longitude campaign of 1878 will illustrate several points of this paper.

The observer at Fort Bliss (latitude 31° 45') frequently inserted stars subpole in his determinations. As a consequence the weight of the final time determination was less, proportionately, than it otherwise would have been; for a zenith star my formula would give

$$\frac{1.3}{1 + 0.\,z \sec^2 31° 45'} = \frac{1.3}{1.415} = 0.919$$

But the group after signals on September 8th contains 11 stars, giving a final weight of 6.92; or about that of 8 or 9 stars nearer the zenith; two stars are below pole, and therefore less advantageous. The results of the individual stars (those north of 65° are marked with an asterisk; these are now between 45° and 65°) are as follows:

	Clock Corr.	Clamp.
	m s	
θ Aquarii	—1 24.79	W
γ Aquarii	—1 24.89	W
π Aquarii	—1 24.82	W
Draconis 9 H. sp	—1 25.28*	W
Groomb. 3834	—1 25.39*	W
ζ Pegasi	—1 24.75	W
λ Pegasi	—1 24.83	E
τ Cephei	—1 25.07*	E
Bradley 1508 sp	—1 25.37*	E
o Andromedae	—1 25.09	E
α Pegasi	—1 24.74	E

The least square solution gives the mean clock-correction —1′ 24″.888, but this includes, with their proper weight, the stars marked with an asterisk. If we omit these, and give all others a weight unity we shall have —1′ 24″.844, or +0″.044 more. But it is plain from least square solution that some cause affects the observations north of the zenith, probably wear of pivots [1]; and the mean of the 6 stars south of the zenith gives —1′ 24″.803;

[1] This is confirmed by the other dates when the same instrument was employed.

the three north of the zenith and above pole $-1' 25''.183$; and the zenith distances are nearly equal for these two groups. It is plain from this that the least square value $-1' 24''.888$ is probably nearer correct than the greater (algebraic) value $-1' 24''.803$; as it ought to be. In other words, the exclusion from the final clock corrections of the quick moving polar stars renders the elimination of pivot error very questionable; as, in fact, does the employment of groups not sufficiently well-balanced.

The simpler method of reduction, which gives the instrumental corrections separately, without least squares, really assigns to the polar stars their proper weight; especially if they are all observed at upper culmination, as the German instructions recommend. For in this case the final clock corrections from each time star are actually reduced by interpolation to the zenith, as may be seen by using Dr. Braun's graphical method given in vol. 109 (No. 2595) of the Astronomische Nachrichten. So that in the previous example it is not surprising that the preliminary solution gave a value ($1' 24''.90$) very nearly equal to the final result. Nor is it very plain that the least square method is absolutely indispensable; I have employed it in my reductions without objection, although I have never known a case in which it materially aided in producing a better agreement in the resulting longitude. The chief argument in its favor here is that it renders it unnecessary to restrict the selection of stars to a narrow range, while it removes the arbitrary character of the reductions when this restriction has not been carried into effect. The chief objection to the method of least squares is that observers who are not both experienced and careful sometimes permit a blind faith in it to mislead them in preparing their working lists; and forget the necessity of making observations enough and of the right quality, which is no less when least squares are used in reductions than at any other time.

Jacobi's theorem is in substance the following; and bears directly upon the point in question:

In order to obtain the least square result for any unknown of m equations with a less number of unknowns, we solve all possible combinations n by n of the m equations, and multiply each such result for this unknown by the square of the corresponding determinant. We add all these products together and divide their sum by the sum of the squares of the determinant factors; the quotient will be the least square result sought for.[1]

To a least square result, then, unfavorable combinations furnish small contributions relatively to favorable ones; and if the favorable ones cannot be made, the unfavorable ones are better than nothing. Stars below pole are the proper ones to employ in combination with those above, when the azimuth is the unknown most needed, as in setting up a meridian mark; but for time-determinations proper the best combination is that of polars above pole with time-stars at nearly equal zenith distances on the other side.

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[1] Jacobi, De Formatione et Proprietatibus Determinantium: Crelle's Journal.

I have annexed to this paper, a table for Ogden observatory, latitude 41° 13′ 8″.6, which is calculated according to the formula.

$$p = \frac{1.3}{1 + 0.3 \sec^2 \delta}$$

$$A = \frac{\sin(\varphi - \delta)}{\cos \delta}$$

$$C = \frac{1}{\cos \delta}$$

The columns p, C p, C^2 p hold good for any station; the values of A p, A^2 p, A C p must be recalculated for every new latitude. But I have not omitted them, as their values will serve as a control for a good many places near the same parallel. The numbers are given to four decimals, to enable the computor to interpolate readily to three.

The 52 nights out of 78 upon which signals were not exchanged at Ogden, afforded an excellent opportunity for the criticism of the instrument. A peculiarity of much far western longitude work is that the telegraph lines are in bad order much of the time, and do not afford opportunities for long exchanges. On some nights of the exchanges with Fort Bliss (Texas), it was impossible to get a circuit through on the more direct route, by way of Cheyenne, Denver, and Santa Fé, and recourse was had to a line of 2,000 miles in length via San Francisco, Southern California, and Arizona. The time expended while waiting is, under such circumstances, best applied to the study of the peculiarities of the instrument.

In conclusion, I will indicate the principal points of this paper as a summary of directions for the determination of time in latitudes 25° to 49°.

1. A group of time-stars should contain about 10 stars in all, with one reversal.

2. It should contain no more than two or three polars; one of which may be within 10 degrees of the pole.

3. Stars north of the zenith, not polars, should be included; and may take the place of polars to some extent.

4. Lower culminations should in general be avoided; and time-stars far south of the zenith.

5. The stars of a group should so balance at the zenith that the co-efficient of azimuth and collination in the normal equation for clock-correction should be very small, and the weight of the clock-correction large in proportion to the number of stars.

6. With proper blank forms the preliminary reduction without least squares can be very simply effected, and this should always be done.

7. The least square deduction is of little benefit except in removing the effect of any arbitrary assumptions in the previous process; and should be

employed only for the signal-nights, or other times when the last degree of precision is required.

8. In making the least square reductions the weights at different declinations should be combined with the coefficients for azimuth and collination; and the unknowns should be in the form of corrections to the values derived from the preliminary reduction.

JACOBI'S THEOREM.

NOTE.—[I give this in the original Latin, as it is very important, and seems not to be well known to mathematicians.]

Proponantur aequationes:

$$ax+a'x,+a''x_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots +a^{(n)}x_n = l$$

$$a_1x+a'_1x,+a''_1\,x_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots +a,^{(n)}\,x_n = l_1$$

$$a_p\,x+a'_p\,x_1+a''_p\,x_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots +a_p{}^{(n)}x_n = l_p$$

Quarum numerus incognitarum numerum excedat; e quolibet systemate n+1 aequationum praecedentium valor incognitae eruatur atque per quadratum Determinantis eius systematis, RR, multiplicetur; quibus factis pro singulis aequationum propositarum combinationis omnium illorum productorum summa per summam omnium RR dividatur: eruitur incognitae valor idem atque invenitur, si aequationes propositae per Methodum Minimorum Quadratorum tractantur."

Observandum est, valores omnium incognitorum qui ex eadem aequationum propositarum combinatione proveniant secundum Prop. praec. per *eandem* quantitatem RR multiplicare, quam ideo in applicationibus ad *Methodum Minimorum Quadratorum convenit appellare Pondus Combinationis*, a pondore valoris incognitae bene distinguendum.

The theorem is thus given in Crelle, vol. 22, p. 316; it is also given independently by Mr. J. W. L. Glaisher in Vol. 40, of the Monthly Notices, p. 607.

SQUARES AND PRODUCTS OF LEAST SQUARE CO-EFFICIENTS FOR TIME — OGDEN.

Decl.	P		A p		C p		A_2 p		A C p		C_2 p	
0°	1.0000		+.6589		+1.0000		.4342		+.6589		1.0000	
		−1		131		+1		−172		−130		+2
1	.9999		.6458		1.0001		.4170		.6459		1.0002	
		2		133		2		168		130		7
2	.9997		.6325		1.0003		.4002		.6329		1.0009	
		3		134		4		166		129		12
3	.9994		.6191		1.0007		.3836		.6200		1.0021	
		5		134		6		164		129		16
4	.9989		.6057		1.0013		.3672		.6071		1.0037	
		7		136		8		160		127		22
5	.9982		.5921		1.0021		.3512		.5944		1.0059	
		7		137		9		158		128		26
6	.9975		.5784		1.0030		.3354		.5816		1.0085	
		10		138		10		155		127		31
7	.9965		.5646		1.0040		.3199		.5689		1.0116	
		10		139		12		152		128		35
8	.9955		.5507		1.0052		.3047		.5561		1.0151	
		11		140		14		148		127		41
9	.9942		.5367		1.0066		.2897		.5434		1.0192	
		13		141		16		147		128		48
10	.9929		.5226		1.0082		.2750		.5306		1.0240	
		15		143		17		144		128		48
11	.9914		.5083		1.0099		.2606		.5178		1.0288	
		17		144		19		141		129		56
12	.9897		.4939		1.0118		.2465		.5049		1.0344	
		19		145		20		139		129		61
13	.9878		.4794		1.0138		.2326		.4920		1.0405	
		19		147		22		135		130		67
14	.9859		.4647		1.0160		.2191		.4790		1.0472	
		22		148		24		133		132		71
15	.9837		.4499		1.0184		.2058		.4658		1.0543	
		23		149		25		130		133		78
16	.9814		.4350		1.0209		.1928		.4525		1.0621	
		25		151		27		127		134		83
17	.9789		.4199		1.0236		.1801		.4391		1.0704	
		27		153		29		123		136		89
18	.9762		.4046		1.0265		.1678		.4255		1.0793	
		28		153		30		121		138		95
19	.9734		.3893		1.0295		.1557		.4117		1.0888	
		31		156		31		117		140		101
20	.9703		.3737		1.0326		.1440		.3977		1.0989	
		32		157		33		115		142		107
21	.9671		.3580		1.0359		.1325		.3835		1.1096	
		34		159		35		110		145		114
22	.9637		.3421		1.0394		.1215		.3690		1.1210	
		36		160		36		107		147		121
23	.9601		.3261		1.0430		.1108		.3543		1.1331	
		38		162		38		104		151		127
24	.9563		.3099		1.0468		.1004		.3392		1.1458	
		41		164		39		100		154		135
25	.9522		.2935		1.0507		.0904		.3238		1.1593	
		42		166		40		95		157		143
26	.9480		.2769		1.0547		.0809		.3081		1.1735	
		45		168		42		92		162		149
27	.9435		.2601		1.0589		.0717		.2919		1.1884	
		47		170		43		87		165		158
28	.9388		.2431		1.0632		.0630		.2754		1.2042	
		50		171		45		83		170		165
29	.9338		.2260		1.0677		.0547		.2584		1.2207	
		52		174		45		79		175		174

SQUARES AND PRODUCTS OF LEAST SQUARE CO-EFFICIENTS FOR TIME — OGDEN.

Decl.	P		Ap		Cp		A_2p		ACp		C_2p	
30	.9286		.2086		1.0722		.0468		.2409		1.2381	
		55		175		47		72		180		188
31	.9231		.1911		1.0769		.0396		.2229		1.2564	
		58		178		48		68		185		191
32	.9173		.1733		1.0817		.0328		.2044		1.2755	
		60		180		49		63		192		201
33	.9113		.1553		1.0866		.0265		.1852		1.2956	
		63		182		50		57		197		211
34	.9050		.1371		1.0916		.0208		.1655		1.3167	
		66		183		51		51		205		221
35	.8984		.1188		1.0967		.0157		.1450		1.3388	
		70		186		52		43		211		232
36	.8914		.1002		1.1019		.0114		.1239		1.3620	
		73		188		52		39		219		242
37	.8841		.0914		1.1071		.0075		.1020		1.3862	
		76		189		52		31		227		254
38	.8765		.0625		1.1123		.0044		.0793		1.4116	
		79		192		53		23		236		265
39	.8686		.0433		1.1176		.0021		.0557		1.4381	
		84		194		53		17		245		+278
40	.8602		.0239		1.1229		+.0007		.0312		1.4659	
40°	.8602		+.0239		+1.1229		.0006		+.0312		1.4659	
		—87		—196		+54		— 6		— 225		+ 291
41	.8515		+.0043		1.1283		.0000		+.0057		1.4950	
		91		197		53		+ 3		265		304
42	.8424		—.0154		1.1336		.3003		—.0208		1.5254	
		95		200		52		12		276		317
43	.8329		.0354		1.1388		.0015		.0484		1.5571	
		100		201		52		22		288		332
44	.8229		.0555		1.1440		.0037		.0772		1.5903	
		104		203		50		34		300		347
45	.8125		.0758		1.1490		.0071		.1072		1.6250	
		109		204		50		41		312		362
46	.8016		.0962		1.1540		.0115		.1384		1.6612	
		113		205		48		57		327		379
47	.7903		.1167		1.1588		.0172		.1711		1.6991	
		119		207		45		71		342		395
48	.7784		.1374		1.1633		.0243		.2053		1.7386	
		123		207		44		83		357		412
49	.7661		.1581		1.1677		.0326		.2410		1.7798	
		129		208		40		99		373		430
50	.7532		.1789		1.1717		.0425		.2783		1.8228	
		135		208		37		114		390		449
51	.7397		.1997		1.1754		.0539		.3173		1.8677	
		140		208		33		131		408		468
52	.7257		.2205		1.1787		.0670		.3581		1.9145	
		147		207		28		148		427		487
53	.7110		.2412		1.1815		.0818		.4008		1.9632	
		152		207		23		168		447		508
54	.6958		.2619		1.1838		.0986		.4455		2.0140	
		158		205		17		187		469		529
55	.6800		.2824		1.1855		.1173		.4924		2.0669	
		165		203		10		208		489		549

SQUARES AND PRODUCTS OF LEAST SQUARE CO-EFFICIENTS FOR TIME — OGDEN.

Decl.	P		Ap		Cp		A_2p		ACp		C_2p	
56	.6635		.3027		1.1865		.1381		.5413		2.1218	
		172		200		+ 2		231		513		571
57	.6463		.3227		1.1867		.1612		.5926		2.1789	
		178		197		—6		254		536		594
58	.6285		.3424		1.1861		.1866		.6462		2.2383	
		184		193		16		279		561		615
59	.6101		.3617		1.1845		.2145		.7023		2.2998	
		192		188		27		305		587		638
60	.5909		.3805		1.1818		.2450		.7610		2.3636	
		198		182		38		333		613		661
61	.5711		.3987		1.1780		2783		.8223		2.4297	
		205		174		52		362		640		684
62	.5506		.4161		1.1728		.3145		.8863		2.4981	
		212		166		67		392		668		705
63	.5294		.4327		1.1661		.3537		.9531		2.5686	
		218		157		82		423		697		728
64	.5076		.4484		1.1579		.3960		1.0228		2.6414	
		225		145		100		457		725		748
65	.4851		.4629		1.1479		.4417		1.0953		2.7162	
		230		133		119		490		754		769
66	.4621		.4762		1.1360		.4907		1.1707		2.7931	
		236		119		139		526		784		788
67	.4385		.4881		1.1221		.5433		1.2491		2.8719	
		242		102		161		561		812		804
68	.4143		.4983		1.1060		.5994		1.3303		2.9523	
		246		85		186		598		840		820
69	.3897		.5068		1.0874		.6592		1.4143		3.0343	
		250		66		211		635		867		834
70	.3647		.5134		1.0663		.7227		1.5010		3.1177	
		253		43		238		672		894		843
71	.3394		.5177		1.0425		.7899		1.5904		3.2020	
		255		—21		268		710		918		850
72	.3139		.5198		1.0157		.8609		1.6822		3.2870	
		256		+ 5		297		746		940		854
73	.2883		.5193		.9860		.9355		1.7762		3.3724	
		256		33		329		781		959		853
74	.2627		.5160		.9531		1.0136		1.8721		3.4577	
		254		62		363		816		975		846
75	.2373		.5098		.9168		1.0952		1.9696		3.5423	
		251		94		396		847		988		837
76	.2122		.5004		.8772		1.1799		2.0684		3.6260	
		246		127		431		877		996		819
77	.1876		.4877		.8341		1.2676		2.1680		3.7079	
		239		162		466		903		998		797
78	.1637		.4715		.7875		1.3579		2.2678		3.7876	
		232		198		501		925		997		767
79	.1407		.4517		.7374		1.4504		2.3675		3.8643	
		220		— 234		— 536		943		988		782
80	.1187		—.4283		.6838		1.5447		—2.4663		3.9375	

SQUARES AND PRODUCTS OF LEAST SQUARE COEFFICIENTS FOR TIME — OGDEN.

Decl.	P	A p	C p	$A_2 p$	A C p	$C_2 p$
80°	0.1187	—.4283	+.6838	1.5447	—2.4663	3.9376
	—207	+ 273	—570	+ 956	+ 973	+ 689
81	0.0980	.4010	.6268	1.6403	2.5936	4.0065
	192	310	603	963	951	640
82	0.0788	.3700	.5665	1.7366	2.6587	4.0705
	175	347	633	964	923	584
83	0.0613	.3353	.5032	1.8330	2.7510	4.1289
	163	385	662	958	888	521
84	0.0457	.2968	.4370	1.9288	2.8398	4.1810
	12	419	686	945	844	454
85	0.0321	.2549	.3684	2.0233	2.9242	4.2264
	114	454	709	925	795	378
86	0.0207	.2095	.2975	2.1158	3.0037	4.2642
	89	484	728	897	738	299
87	0.0118	.1611	.2247	2.2055	3.0775	4.2941
	65	513	741	865	676	217
88	0.0053	.1098	.1506	2.2920	3.1451	4.3158
	40	538	751	826	608	131
89	0.0013	.0560	+0.0755	2.3742	3.2059	4.3289
	—13	560	755	776	536	+44
90	0.0000	0.0000	0.0000	2.4518	3.2595	4.3158
	+13	577	755	722	460	—44
89 sp	0.0013	+0.0577	—0.0755	2.5240	3.3055	4.3289
	40	590	751	664	381	131
88 sp	0.0053	.1167	.1506	2.5904	3.3436	4.3158
	65	599	741	603	301	217
87 sp	0.0118	.1766	.2247	2.6507	3.3737	4.2941
	89	603	728	634	220	299
86 sp	0.0207	.2369	.2975	2.7041	3.3957	4.2642
	114	603	709	467	140	378
85 sp	0.0321	.2972	.3684	2.7508	3.4097	4.2264
	136	598	686	397	+60	554
84 sp	0.0457	.3570	.4370	2.7905	3.4157	4.1810
	156	591	662	327	—15	521
83 sp	0.0613	.4161	.5032	2.8232	3.4142	4.1289
	175	578	633	257	88	584
82 sp	0.0788	.4739	.5665	2.8489	3.4054	4.0705
	192	564	603	187	158	640
81 sp	0.0980	.5303	.6268	2.8676	3.3896	4.0065
	+ 207	+ 544	—570	+ 121	—222	—689
80 sp	0.1187	+.5847	—.6838	2.8797	—3.3674	3.9376

THE SO-CALLED ELEPHANT MOUND IN GRANT COUNTY, AND EFFIGIES IN THE REGION SURROUNDING IT.

By Rev. S. D. PEET.

The survey of the mounds in the neighborhood of the so-called elephant effigy, which was undertaken under the auspices of the Wisconsin Academy of Arts, has not, for various reasons, been reported until now. The survey was conducted by the writer mainly during the year 1885, but a trip previous to that in 1882, and subsequent to it in 1886, are to be taken into the account. It is very fortunate that the Society recommended this survey at the time that it did, as many of the mounds then in a good state of preservation, have been destroyed since. A railroad has been built along the valley of the Mississippi and the track has been laid in the very midst of the mounds that were surveyed. Before giving a description of the survey we propose

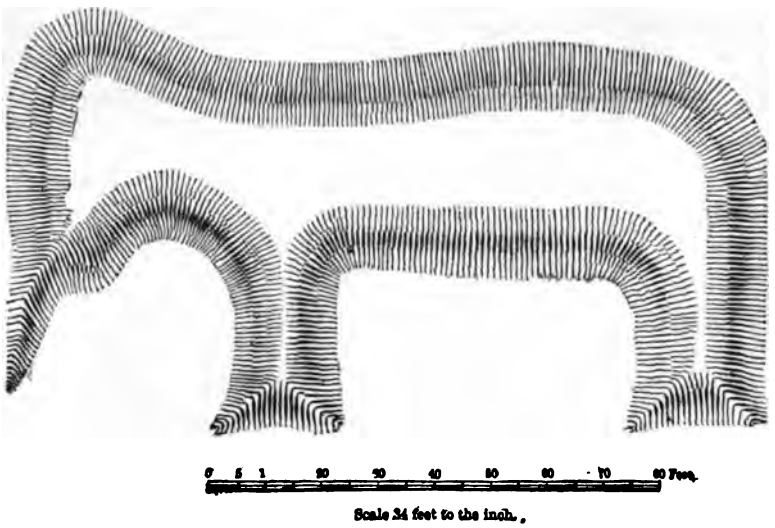


Fig. 1.

to give a history of this effigy. The discovery of the elephant effigy was made by Mr. Jared Warner, of Patch Grove, Grant County, and the account was first published in the Smithsonian report of 1872, with a cut, an electrotype. (See Fig. 1). Mr. Warner says "this effigy was situated on the high sandy bottom lands of the Mississippi, on the east side, about eight miles below the mouth of the Wisconsin river. There are on each side of

the mound, some fifteen or twenty rods distant, sandy, grassy ridges, some fifteen feet higher than the land about the mound; the mound is, therefore in a shallow valley, sloping gently to the Mississippi river, and only about eight feet above high water. Its total length is 135 feet; from hind feet to back, sixty feet; from fore feet to back, sixty-six feet; width across fore legs, twenty-one feet; across hind legs, twenty-four feet; space between hind and fore legs, fifty-one feet; from end of proboscis to fore legs, thirty-nine feet; across the body, thirty-six feet; general height of body above surrounding ground, five feet. The head is large, and the proportions of the whole so symmetrical that the mound well deserves the name of the "Big Elephant Mound." Next to Mr. Warner was Mr. Moses Strong, who published an account of the effigy and the mounds surrounding it in the Smithsonian Report for 1876. Mr. Strong was at the time connected with the Geological survey of the state, and took in the exploration of the mounds incidentally. He describes a group of mounds on the Mississippi bottom situated on Sec. 17, N. E. quarter Tp. 5, R. 6 W. [The effigy is on Sec. 21].

Mr. Strong says, "following the course of the Mississippi about a quarter of a mile southeast of the preceding locality, numerous long mounds are seen arranged in several rows parallel to each other and to the river. They are situated in the cultivated fields and are nearly obliterated. At the time these localities were visited the valley was covered by a crop of standing corn which rendered it difficult to find them; and it is probable that many exist which were not noticed. No circular or effigy mounds were found in connection with them. Continuing down the valley we come to a group in which the three kinds of mounds are well represented. They lie upon the alluvial bottom quite near a bayou of the Mississippi and none of them are more than eight feet above high water mark, while those in the southern part of the group are not more than three feet. In this group where all kinds are represented, there seems to be a separation of the long and round mounds from each other. There is nothing of peculiar interest in the occurrence of the long and circular mounds, but we have here two quite singular effigies. The central one of the group is evidently intended to represent a bird with the wings spread in the act of flying; the head is directed to the south. The wings measure ninety-four feet each way from the center of the body to their extremities, and the length of the tail is sixty-five feet. It is quite a large and well-formed effigy and is different from the other bird mounds in having an angle in the wings. Situated at the northern end of the group is the most interesting effigy mound any where observed. A description of it by Mr. Warner, of Patch Grove, was published in the Smithsonian Report of 1872, page 416. It is known as the "Elephant Mound," and as it lies upon the ground it resembles an elephant or mastodon, much more closely than any other animal, and the resemblance is much more perfect in this instance than in other effigies. This mound, in common with all the rest in the group, has been under cultivation; and on account of its size, special efforts have been made with plows

and scrapers, to bring it to the level of the adjacent field. Its size alone has protected it. These efforts have resulted in diminishing its height, increasing its width and general circumference, and rendering its outline somewhat indistinct so that it was difficult to make exact measurements."

The writer first visited the effigy six years after Mr. Strong made his report. It was then nearly obliterated. Subsequent to this first visit the employes of the Ethnological Bureau suryeyed some groups of mounds and effigies on the bluffs, three miles north of the effigy, but their report has not yet been published. Subsequent to their survey, Mr. Brown, a student in Wisconsin University, and an assistant of Prof. Conover, of Madison, Wis., was employed to make measurements of the mound, so that a cast might be made of it and put on exhibition with the Smithsonian relics, at the New Orleans Exposition, during 1885. The exploration of the writer under the auspices of the Society was subsequent to all these. It embraced not only the so-called elephant effigy, but all the mounds in the vicinity. The mound was again measured, making the fourth actual survey.

The following is the result of the personal examination of the mound at this time: When the the writer visited the locality in 1885, only two mounds out of the whole group were left, one which is described as the bird effigy, the other known as the elephant mound. Both of these had been nearly plowed down, but owing to peculiar circumstances were plainly visible. During the spring preceding the visit, the water from the bayou had set back into the swail and remained standing upon the low ground, but did not quite reach to the summit of the effigies. There was at the time a growth of clover upon the soil, but this was drowned out by the flood except where the effigies stood. As a result the effigies were covered with the clover, but the surrounding ground was either bare or had a slight covering of grass upon it. Standing upon the summit of the hill or ridge adjoining, we were able to look down upon the swail and see the outlines of the two effigies, the dark color of the clover contrasting with the light shade of the grass. The shapes of the two effigies were easily made out. The bird had its head toward the southwest, its wings extending across the swail, nearly reaching the foot of the sand ridges. The so-called elephant effigy had its head in the same direction, to the southwest, but its body was lengthwise of the swail, its heavy legs extending toward the southeast. The two effigies were in contrast, as the bird had long, narrow wings, small body and neck, while the animal had a broad, heavy body,almost square in shape, with its legs unusually wide and clumsy. On approaching nearer the outlines of the effigy were not so distinct as when at a distance, though the clover seemed to give it an elevation. The real mound was but slightly raised above the surrounding surface and there were no sharp lines to the effigy.

The measurement of the mound was very unsatisfactory on account of the condition in which it was. The figures would not represent the mound as it was when first seen, and would be very unreliable as there were no

points from which to begin or end the measurement. One thing was noticeable, however, to the eye and confirmed by measurements. There was no proboscis to the figure. The point which extended from the nose was indistinct and appeared to be the result of the washing of the sandy soil down to the level. It was evident that that which was taken for the proboscis was never long enough or wide enough to properly represent that part. The writer has had considerable experience in tracing out mounds which were nearly obliterated and ordinarily would be able to describe the figure from what might be called the shadow of it. The peculiar color of the soil, which originally belonged to the figure, and the indescribable shading of this soil into the undisturbed surface of the soil or ground surrounding it, will ordinarily give the figure to the eye, even if the measurements should be unsatisfactory. The impression formed by this effigy, and especially the part of it which is the distinctive and deciding point was that the proboscis was never there. The writer hesitates to put himself on

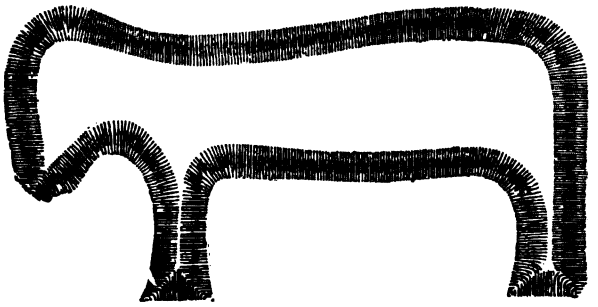
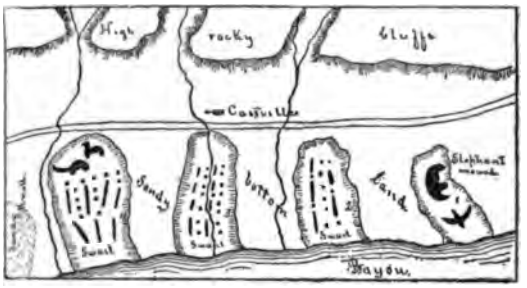


Fig. 2.

record as contradicting such reliable persons as have given a description of the effigy to the public. There is this, however, to be considered. If the engraved figure which was made according to a scale from the measurements of Jared Warner, and those accompanying him, should be taken, and the narrow, pointed snout left off from the figure as uncertain, we should have an effigy which bears very little resemblance to the elephant. (See Fig. 2.) On the other hand, if any one undertakes to draw the figure so that it shall have the trunk in its usual place and shape he would have to completely overdraw and distort the figure, as it is now. This view led the writer, at his first visit, to doubt the intent of the effigy, and every other visit has increased the doubt. The examination of the effigy itself proved so unsatisfactory that the writer determined to study and survey the groups adjoining, and therefore a description of these groups is added to the report. It should be said that the study was given first to the groups on the bottom-lands, then extended to the bluffs, and afterward the whole region was traversed and examined, until all the groups in the vicinity were explored. These will be given in their order.

We call attention to the mounds in the immediate vicinity of the so-called elephant effigy. The writer traversed the region in a reverse order or direction from that which Mr. Strong pursued, but was able to identify some of the groups which he mentions. There were no effigies in the vicinity, except two, which were very nearly obliterated.



There were several groups in the swails which cut through the bottom land in this vicinity, and to these we first gave our attention. The swails are the dry beds of water courses, which in the time of heavy rains, flow out from gorges or so-called "coolies" in the bluff toward the bayous of the river. These swails are generally in a direct line with the openings in the bluffs, and extend from the foot of the bluffs across the sandy bottom land or terrace to the bayous. They are so much below the surface that the mounds in them are not seen until one suddenly comes upon them as he reaches the edge of the swail. The swail in which the so-called elephant mound was placed was not exactly in a line with the rest but angles to the southwest, and where the effigy is, was much deeper than the other swails. The method of arranging these mounds in the swails was peculiar. They were placed in parallel rows which extended lengthwise of the swail, sometimes three or four rows in each swail and in some of the swails as many as thirty or forty mounds in a group. Four such groups were discovered by the writer in passing from the elephant mound, northward, the most of them composed of alternate rows of long mounds and round mounds, arranged in parallel lines. There were no effigies in the swails, merely round and long mounds. The only place where effigies were discovered was on the terrace or bottom land outside of a swail about a mile north from the elephant effigy, on what was called the Bagley place. These effigies were nearly obliterated but seemed to have been very large in size, and possibly one or two of them may have resembled in shape the effigy which is called the elephant. But the figures were so far gone that no effigy could really be traced.

It should be said of these that if one were determined to make out the existence of the elephant and camel effigies, the shadowy shape left upon the surface of the soil might easily satisfy him. There were two

figures. One with a large body and a snout (Fig. 3) extending from it to a great length, curved somewhat like the horns of the mastodon. The other with a body slimmer and not so large, but with a long neck protruding above the body. Still no man of candor would undertake to build up a theory on so shadowy a foundation as this, for we have only to reverse the figure to make it represent a gigantic raccoon instead of an elephant, and the theory is upset. In reference to the different groups of mounds, which were found in the swails, we should say that they belonged to the same age as the so-called elephant effigy, and yet there was a fresh look to them, as if they were of a comparatively recent date. It would hardly seem possible for mounds to be preserved in the sandy soil, during the many centuries which have elapsed since the mastodon became extinct, and the theory that they were built at the time of the mastodon seems untenable. The evidence that they belonged to the same time and belonged to the same people, is that they were situated in the same kind of swails and were arranged in the same order, and at the same time were near the group in which the effigy is found. The probabilities then are against this effigy being an elephant, and the figure is given only to show how easily one may be mistaken.

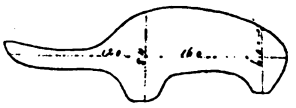
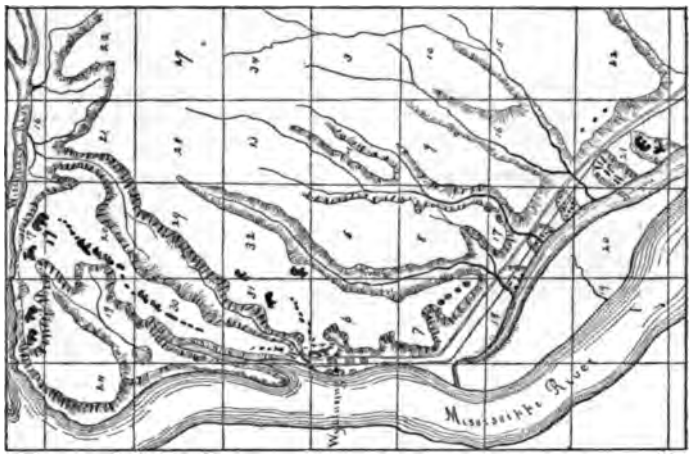


Fig. 3.

The examination of the effigies and mounds on the bluffs followed that of the mounds on the bottom lands. It should be said that the bluffs, in this region, are very precipitous, and are broken into narrow and crooked ridges, on either side of which the water courses through deep gorges, down to the streams and water-spouts, until it makes its way to the bayou and to the river. The only way to reach the summit is to climb the precipitous face of the cliff, or to follow up the narrow and crooked valley of the stream to the plateau above, and then retrace one's steps out on the level to the edge of the bluffs. When one reaches the summit from either direction he is pretty sure to find mounds on the ridge. They are hidden from view until he reaches the hill-top, but they run in long lines from the edge of the cliff back to the plateau at the head of the gorges. A perfect net-work of these long mounds, round mounds, and effigies, was discovered, nearly every ridge having its own line, but some of the ridges having lines that were connected. They seem to be the most numerous on the bluffs which intervene between the Wisconsin and Mississippi rivers, and yet we understand that others are to be seen on the bluffs immediately overlooking the so-called elephant effigy. The lines of mounds extend to great distances, some of them three or four miles in length, and it was not difficult to imagine them to be sort of elevated roadways con-

necting lookout stations, on which warriors might watch the enemy coming down the Wisconsin river, or up the Mississippi river, and so notify the people residing in the village of the danger that threatened them. At least the lines of long mounds and round mounds seem to follow along the ridges which intervene between the two rivers, as if the object was to connect the valleys by lookout stations and elevated roadways. The view from the edge of the high bluffs is always extensive and commands the bottom lands below. There are, however, lines which extend from the face of the bluffs back to the prairies and open plateau in the interior, and an explanation of these would be that they were elevated ways on which hunters might run while watching the game that should be driven from the plateau down the gorges to the bottom land below.



Map 1.

The explanation, however, is not the purpose of the survey, but merely the statement of the facts. The long lines of mounds on the bluffs, all seem to have effigies, and the object was to ascertain what kind of effigies they were. The lines which were followed out were more or less directly connected with the group in which the elephant effigy was situated, at least they were on the bluffs which overlooked the same terrace and we understood some of them were on the edge of the same gorge through which the water would make its way, while passing through the swail where the effigy mound is seen. The elephant effigy forms the southernmost limit; but the northern limit of the long mounds and effigies upon the bluffs is seven or eight miles distant, on the Wisconsin river. The groups on the bottom lands and on the bluffs adjoining, seem to form connecting links, so that if one were to study one group, he needed to study all. There are three or four lines of effigies on the bluffs and three or four groups of parallel mounds on the bottom lands. One object was to see if there was any connection between the different parts of this system. Another object was to

examine the different effigies on the bluffs and compare them with those on the bottom lands and ascertain the character of both. A third object was to ascertain whether there was any effigy on the bluffs which in any way had resemblance to the so-called elephant effigy on the bottom lands. With these three questions in mind, the exploration was undertaken. It was not an easy thing to do, as the gorges were long and the bluffs were steep, but it was accomplished by the aid of a guide who knew the location of all the groups. We take up the groups or lines of mounds on the bluffs in their order, and call attention to the map of these different mounds as well as the topography of the country in which they were fonnd. We give the names of the people who owned the land, and call the groups by the name of the place. (1) The group on the Kendall place. This is composed of a series of long mounds and effigies which run from tbe edge of the bluff, overlooking the village of Wyalusing, out across land belonging to Mr. Glenn, Sec. 31, to land belonging to Mr. Kendall, on Sec. 32. This group or line of mounds overlooked the gorges on either side, and extended out to the level plateau at the head of the gorges. The line was composed mainly of long mounds, but the effigies were situated at either end of the line, the effigy of a squirrel being at the west end of the line on the edge of the bluff, and three effigies at the east end of the line; a moose, wild cat, and bear. The squirrel was a very unique and interesting effigy, representing the animal as in the attitude of running; the wild-cat was of the ordinary shape, but the moose was the most interesting of all. It was situated on the edge of the bluff overlooking a deep gorge, south of it, and commanding a view of other effigies on the other side of the gorge. (See map 1, the works in Grant Co., also Figs. 4 and 5.) The attitude of the moose was very natural.

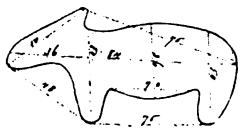


Fig. 4.

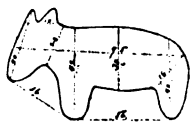


Fig. 5.

We call attention to the different effigies found in these groups, as the answers to questions asked will be found in them. It will be noticed that there are no elephant effigies in any of the groups. The effigies as discovered are as follows: (1) The squirrel on the bluff overlooking Wyalusing, map 2, Section 31. (2) The moose, Fig. 4, situated at the head of the gorge on the Kendall place, Section 32. (3 and 4) The bear and the wild-cat situated in the same group. (5) Raccoon on the Darby place, Fig. 5, Section 31. (6) The buffaloes on the Glenn place, Section 30. (7 and 8) A group of bear and three deer on the Locke place, Section 17. See Fig. 6. (9) Two buffaloes on Section 18, Figs. 7 and 10. A group of turtles on the Senee place, Section 22. These were just such effigies as are common throughout

the state, though the attitude of the squirrel and buffalo and stag or deer were quite unique and interesting. They represent the animals which formerly abounded here. We cannot resist the impression that they represented the animals which were hunted and for which the mounds were erected as observatories. They possibly may have been the "dream gods" or "dream totems," or they may have been "game gods" or "game totems," both signifying the same thing to the superstitious hunters. There was nothing which had any resemblance to the elephant or could convey the idea that the elephant or mastodon was hunted or even known by this people.

The locality which was next examined was north of the Wisconsin river, in Crawford county. This is a region which has been explored by the assistants of the Ethnological Bureau, and we need not dwell upon it in detail. It will be sufficient to say that an interesting discovery was the result of the exploration by the writer. It was found to be the residence of a clan, the swallow being the totem of the clan. We speak of this because it is important, as throwing light on the so-called elephant effigy. The point in mind is this: The swallow which was everywhere discoverable in all the groups visited in Crawford county, shows that this was a totem of this region; and the probability is that the buffalo, which is the most num-

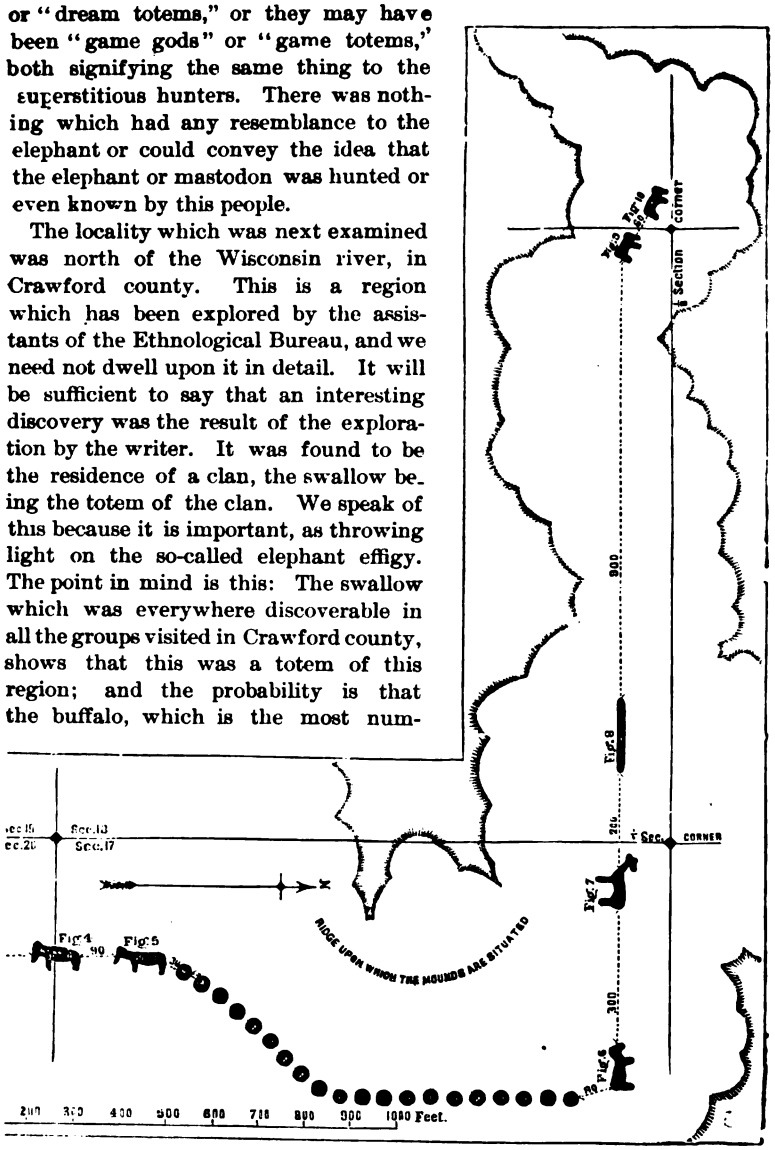


Fig. 6.

erous and prominent effigy in Grant county, was the totem of that region. If this is so, then we have an additional reason to believe that the so-called elephant effigy was nothing more nor less than a buffalo, and represented the totem of the region. We have this to contend with, however,—it was maintained by Dr. J. W. Phene, that he discovered in Campbell coolie, three miles north of Prairie du Chien, the effigy of a camel, and that the camel and elephant were associated in the mound-builders' art. The search was in part for this camel effigy, and in part to ascertain whether the theory of game drives, dream gods, and clan totems, could be carried out by the facts. The result was that the clan totem was ascertained and the theory of the game drive was rendered even more probable.

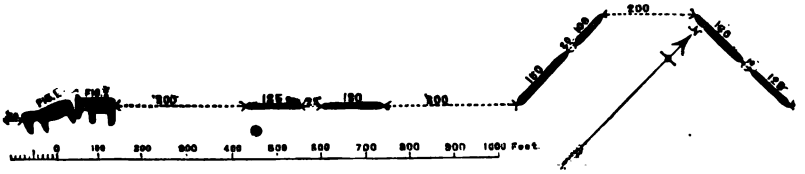
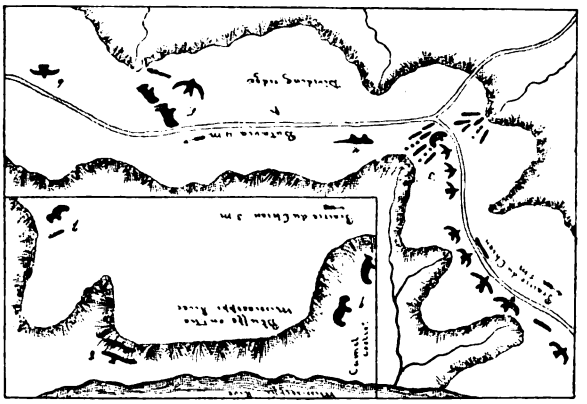


Fig. 7.

We shall illustrate the points. There are seven or eight groups on the bluffs adjoining Prairie du Chien extending along the road from Prairie du Chien to Batavia. In all these groups the swallow is most prominent. In one group, which was composed in part of long mounds, round mounds and effigies, the swallow was associated with the buffalo. (Map No. 2). In another group it is associated with two effigies of bears. (Map 2, No. 5. In a third, situated near the village of Batavia, it is isolated, and yet other effigies



Map 2.

may have been at one time near it. The groups were all situated on a ridge, but at points where the ridge was the narrowest, and where the impression was that the different kinds of game made their way across the ridge from the Mississippi river to the Kickapoo. In passing down to the val-

ley of the Mississippi other effigies were discovered. Two wolves on the side of the bluff, five miles north of Prairie du Chien (Map 2, No. 9), on the Brush place, and two effigies nearly obliterated, on the Dousman place.

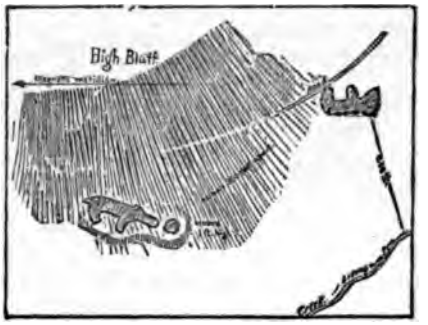


Fig. 8.

One of these we took to be the effigy of the camel, concerning which Dr. Phene and Mr. L. H. Lewis, had spoken, but we could discover no resemblance to that animal. The hasty exploration of all these groups was made in company with Dr. Cyrus Thomas, of the Ethnological Bureau, Washington, D. C., and two of his assistants. Their attention was called to the location of the groups and the theory of the game drives seemed to commend itself as a good explanation of the reasons for their erection. On the way back the party passed a group of large conical mounds, situated on the bottom lands, near the Courliss Bayou. Dr. Cyrus Thomas advanced a theory in reference to these, which seemed very plausible. It was that the mounds were made large and flat so that they could be places of refuge in times of high water. These mounds were arranged in a large circle enclosing an area of about twenty or thirty acres. The impression made upon the writer was, that it was a village site, possibly the site of the village of the very people whose game drives had been discovered upon the hill-tops. The gorges and roadways from the bottom lands to the bluffs and the summit of the ridges, seemed to concentrate near this point. Other groups of large mounds, were, however, visited subsequently, and one of them was found to have an effigy near it. It is probable that several villages existed on this prairie at different times. Which one belonged to the effigy-builders is uncertain.

The discovery of the clan totem was subsequent to this. At a point, three miles south of Prairie du Chien, there is an effigy of a swallow (Fig. 9) situated on the edge of the bluff and overlooking the Wisconsin river. The swallow has its wings spread, but the peculiarity of the effigy is that where the wings are spread to the widest fan, the bluff itself assumes the shape of the wing. Where the body is, the ridge is sharp and narrow, so sharp and narrow that the head and tail of the bird are built out from the sides of the ridge, making it seem as if the body were dropped down below the wings.

It was a singular freak for the people to have erected the effigy in such a place! but no doubt the shape of the bluff or rocky spur suggested the effigy. The clan totem found its embediment in the rock, or at least it was so imagined to be by the builders.

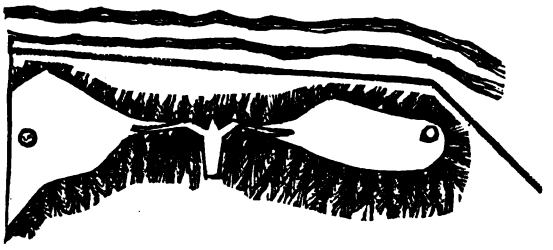


Fig. 9.

Confirmatory of this theory of the clan totem was a discovery made a few days after on the Kickapoo river. At the mouth of this river near the village of Wazeka, there is a group of long mounds and effigies, one of them the effigy of a weasel. Five miles north of Wazeka two other effigies were discovered, both of them swallows. One of these was situated on the top of a very high hill, which overlooked the valley of the Kickapoo and which commanded a view of nearly all of the groups which were previously visited, especially those on the summit of the ridges near the village of Batavia or Eastman. It was a lone swallow and seemed to mark the border line of the swallow clan. The other effigy was situated in a very retired and lonely spot, down near the the water's edge at a bend of the river and hidden away among the surrounding hills. This also was a lone bird. Its wings stretched from bank to bank across the bend of the river, and it covered the bottom-land. The impression formed from these two effigies was that the Kickapoo river was occupied by the swallow clan.

In all these groups which were situated north of the Wisconsin river there were no effigies which resembled in any way an elephant. There were effigies of bear, buffalo, wolves, birds and weasels, but the most numerous and common was this effigy of the swallow. This completes the report of the survey of the effigies in the vicinity of the so-called elephant mound of Grant county. There were, however, about this time various reports published concerning the discovery of elephant effigies in other parts of Wisconsin, and the writer took pains to visit these localities.

The following facts are presented as supplementary to this description of the survey. The place which was visited by the writer to ascertain the facts about a rumored elephant effigy was in Green Lake county, not far from the city of Ripon. It should be said the discussion about elephant pipes which was conducted between Mr. Chas. E. Putnam, Esq., President of the Davenport Academy of Science, and Mr. Henry W. Henshaw, of the Ethnological Bureau, during the year 1885, gave additional interest to the

survey of the effigy mounds and led many of the archæologists, to notice every report of the discovery of new elephant effigies. When, therefore, Mr. Theodore F. Wise, who was at the time publishing a monthly paper, called "The Young Mineralogist and Antiquarian," made the announcement that he had discovered an elephant effigy in the vicinity of Green Lake county, it seemed desirable to the writer that the place should be visited and the facts about the effigy be ascertained. The extension of the survey and a report of it will therefore be excusable. The trip resulted in some very interesting discoveries, but in the refutation of everything which was announced by Mr. Wise in reference to the effigy. The neighborhood of Green Lake is very interesting on account of the number and variety of its effigies. Here on the west side of the lake, situated on the summit of the bluffs and overlooking the water, the writer discovered many beautiful effigies a large majority of them being in the shape of squirrels. The squirrels were in every conceivable attitude, some of them of large size.

On the south end of the lake a group was discovered which contained the effigies of two bears and a deer in the attitude of running. There were also various groups of effigies on the southeast side of the lake. Some of these were birds, some panthers and a few turtles, but many of them were squirrels. (See Fig. 10.) The impression formed by the survey was that here was a clan residence, and that the reason for the erecting of these effigies on the various bluffs, was because the totem of the clan was that of the squirrel. The trip was extended to the shores of Lake Puckaway. Here on the south side of the lake, there are many mounds and effigies. One long row of mounds was followed for the distance of three miles; the row was situated on the edge of the bluff overlooking the lake, and consisted of long mounds, round mounds and various effigies, among which were the bear, and a fox represented as running with his head turned around and looking behind him, a very interesting effigy. A number of groups were discovered also upon the north side of the lake, one of them near the Chicago club-house. This was also in the shape of a squirrel, but a squirrel in a peculiar attitude. There were no effigies resembling the elephant, anywhere on either of the lakes. A gentleman who attended the writer in his explorations at Lake Puckaway (Mr. A. Aldrich, of Green Lake) gave information in reference to the so-called elephant effigy, and volunteered to be a guide to the spot. Accordingly, on the return trip, we went in search of the effigy, and in a field which had been plowed for many years, discovered a number of round mounds, and one that looked as if it might have been an effigy at one time, but it was so far obliterated that no shape whatever could be made out. This was at Dautz Tavern, half way between Green Lake and Lake Puckaway. Mr. Aldrich informed the writer that he was with Mr. Theodore S. Wise when he examined this mound, and that at that time it was in the same condition that it was when we visited it. The resemblance to an elephant was wrought out of the imagination of Mr. Wise, but had no existence. In fact it was im-

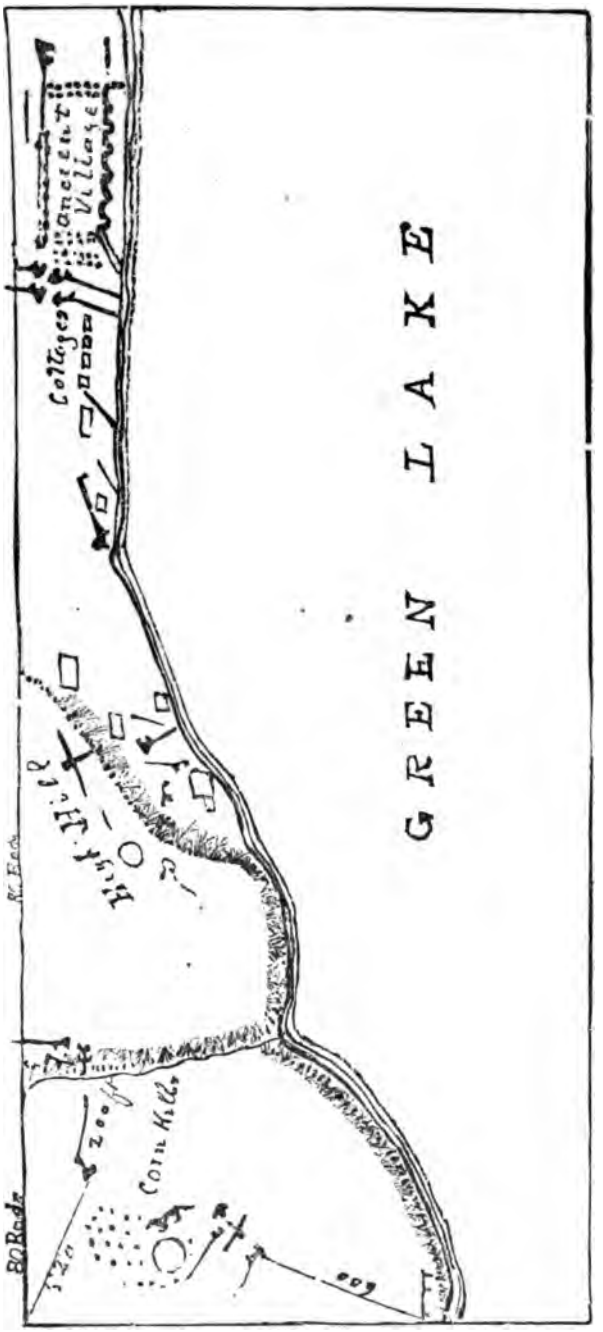

GREEN LAKE
Ancient Village
Cottages
High Hill
Corn Hill
80 Rods

Fig. 10.

possible to trace a single outline that would give the idea that it was an elephant effigy. This finished the search, for it was evident that the effect of the discussion was to create these imaginary figures, and it did not seem worth while to follow up uncertainties. The theory in reference to the clan emblem was confirmed, and the impression was made all the stronger that the effigies of Wisconsin were imitations of the animals which were once common in the region, and that no extinct animal is to be found represented by them.

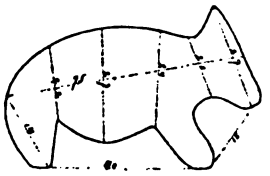


Fig. 11.

A few words more in regard to the effigies, which might be easily mistaken for the elephant. There are two effigies at Merrill Spring, near Madison (see Fig. 11), which have been by some supposed to represent elephants. They are probably effigies of buffalo. They are placed around a large conical burial mound, or lookout station, in the midst of a group which was designed to guard the camping place at the spring. There is also an effigy on Peck's place near the city of Beloit (see Fig. 12),

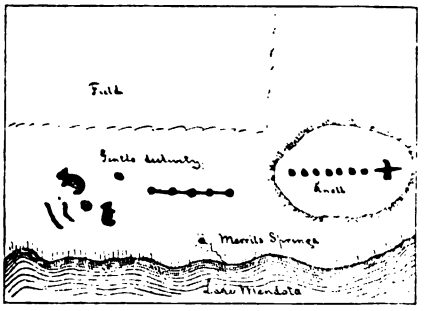


Fig. 12.

which at first sight resembles an elephant. It has the sloping rump and large, heavy body of the elephant, but lacks the proboscis. There is a projection above the head which is probably designed to represent horns. This is in the midst of a buffalo game drive, and represents the dream god, or game god, or fetish, of the hunters. There was formerly a large effigy on the Downe place, east of Beaver Dam. It is nearly obliterated now, but formerly represented some four-footed animal, such as bear, buffalo or moose. It might have been mistaken for an elephant. There is a mound which Mr. T. H. Lewis discovered on the bluffs on the west side of

the Mississippi river, opposite Prairie du Chien, which he says "resembles an elephant." It is probably a buffalo. Other mounds might be mentioned, and among them the group which was one of the earliest discovered in the state, namely, the group described by Mr. S. Taylor, and situated near Blue Mound. (See Figs. 13 and 14). One of these resembles the figure which

Fig. 13.

we have drawn out of the so called elephant effigy, and we therefore give it as a specimen. Our conclusion after all this exploration is that there are no

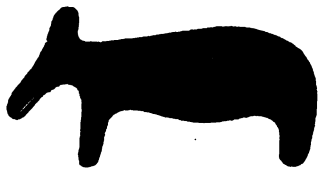


Fig. 14.

elephant effigies in the state, and that the so-called elephant mound was designed to represent either the bear, the wild-cat, the buffalo, or the moose, every one of which contains the same elements of a heavy body, a large head and a protruding snout, and any one of which might might be made to represent an elephant if we would cut off certain parts of the head, and add to other parts.

SPIDERS OF THE SUB-FAMILY LYSSOMANÆ.

BY

G. W. AND E. G. PECKHAM AND WM. H. WHEELER.

INTRODUCTION.*

Up to the present time there have been formed in the sub-family Lyssomanæ, six genera, in the following order of time:

1844. Lyssomanes Hentz.
1869. Asamonea Cambridge.
1872. Jelskia Taczanowski.
1877. Evenus † Simon, Athamas Cambridge.
1885. Simonella Peckham.

Some time ago M. Eugén Simon, with great generosity, placed a number of his unpublished species at our disposal; we have also an undescribed species of Lyssomanes from a collection of Attidæ belonging to the Berlin Museum, which was loaned to us through the courtesy of Dr. Ferd. Karsch; these additions to our own collections have enabled us to add seventeen new species to the thirteen already known in this sub-family.

We wish to express our gratitude to Dr. L. Taczanowski for specimens of all of his species of *Jelskia*, and to to the Rev. O. P. Cambridge for a specimen of *Athamas whitmeei.*

We have endeavored to separate the species into natural groups and to define the groups as closely as possible. The genus *Jelskia* we have included as a sub-genus under *Lyssomanes*, giving the new sub-generic name *Maroussa* to the other species of the genus. The sub-divisions of *Maroussa* and *Jelskia* are merely for practical convenience.

It seems probable that many of the spiders of the Lyssomanii group are adorned, in life, with delicate and brilliant colors which disappear in alcoholic specimens. This we know to be the case with *Lyssomanes viridis* which is in reality of a tender grass-green color but which appears in collections to be of the light yellowish tint which is common to many related species as known to us. The only way to define spiders of this group satisfactorily is by their anatomical proportions and by their epigynes and palpi, which should always be referred to in determining species.

Our measurements have been made in accordance with the following rules:

To determine the length of the cephalothorax, measure from the anterior edge of the eyes of the second row to the posterior edge of the thorax.

To determine the length of the cephalic part (or of the quadrangle of

* The plates for this article were contributed by the authors.

† Afterwards changed to Epeus Peckham.

eyes), measure from the anterior edge of the eyes of the second row to the posterior edge of the eyes of the fourth row.

Where the expression "width of the quadrangle of the eyes" is used, the greatest width is always meant.

The position of the eyes of the third row is determined by measuring from the posterior edge of the eyes of the second, and the anterior edge of the eyes of the fourth row.

DISTRIBUTION OF THE LYSSOMANII.

The distribution of the species of Lyssomanii presents some interesting facts. The genus *Asamonea* falls very naturally into two divisions. The two species constituting the first division, *A. gracilis* and *A. flava*, are confined to South America; the four species forming the second division are restricted to Southern Asia and South Africa. At first sight it would seem well to have formed two genera, allotting to each the Asemoneæ of a hemisphere. Careful study of the species, however, has convinced us that such a proceeding would have been unadvisable, as the morphological characteristics of either group could not be raised to generic importance.

All ten species of Lyssomanes belonging to the sub-genus *Jelskia* are confined to Central and South America. The sub-genus *Maroussa* resembles *Asamonea* in that its species are divided between two hemispheres. One species only, *M. modestus*, is reported from the old world, occurring in Madagascar; of the remaining seven new world forms, five occur in South America, one in the island of San Domingo and one in the southern states of the Union.

Regarded as an isolated fact, this distribution of the members of a genus over the tropics of two hemispheres seems anomalous. But analogous cases in the distribution of other organisms are by no means rare. Among plants especially such cases are common. Among animals we may cite the case mentioned by Wallace of the four species of *Megacephala* (a genus of the Cicindelidæ, or tiger beetle family) two of which occur in Africa and two in South America. In like manner four species of another genus, *Peridexia*, of the same family, are equally divided between South America and Madagascar. Then again when we consider the great antiquity of the existing genera of spiders, we can see nothing difficult of explanation in the wide and discontinuous distribution of the Asamoneæ and Maroussæ. We have only another instance confirmatory of the truth of Wallace's remarks that "Insects exhibit in a very marked degree in their actual distribution the influence both of very ancient and very modern conditions of the earth's surface. The effects of the ancient geographical features of the earth are to be traced in the large number of cases of discontinuous and widely scattered groups which we meet with in almost every family, and which, to some extent, obscure the broader features of distribution due to the period during which the barriers which divide the primary regions have continued to exist." *

* A. R. Wallace, Distribution of Animals, Vol. I, p. 503.

The absence of Lyssomanii in Europe and northern Africa would seem to indicate that the ancestors of this group of spiders during the miocene tertiary ranged through northern Asia and what is now British America. The connection existing between Alaska and northeastern Asia, as shown by the flora of that epoch, would present no obstacle to a group of spiders originating on one of the continents passing over into the other. The advent of the Glacial Epoch, we may suppose, drove the Lyssomanii, which even then had separated into two genera corresponding to our Asamonea and Lyssomanes, members of both of which occurred on either continent, southward, on the one hand through Asia and on the other hand through North America. The distance which the species are driven is considerable, as none seem to have remained on what is now the Asiatic Continent, but all passed over to Ceylon and the neighboring Madagascar, whence some probably wandered to South Africa. Similarly in North America the species were forced southward to Central America, whence some migrated to South America. Here the conditions were most favorable to the development of species as the majority of existing forms is reported from this continent. It is still doubtful whether or not the single species in the island of San Domingo and the single species in the southern United States are to be regarded as forms which were left behind in the wholesale migration of the group or whether they are species which have migrated northward from South America since the close of the Glacial Epoch. We incline to the latter supposition, since it is more probable that a limited number of species would undertake a northward migration than that such a limited number would be spared under conditions which were fatal to the existence of a whole group in the eastern hemisphere. It is, of course, also possible that the Central American species have migrated northward since the close of the Glacial Epoch.

It is interesting to note a somewhat similar distribution in another family of spiders, the Archaeidæ. This family includes four genera; one of these is extinct, and is represented by fossils in the Baltic amber of the Tertiary period; of the three genera that are represented by living species; one is found in Madagascar, one in western Africa, and one in the southern part of South America.*

FAMILY ATTIDÆ.

SUB-FAMILY LYSSOMANÆ.

Eyes in four transverse rows.

Group I. Lyssomanii. Cephalothorax low or moderately high, rather elongated, longer than wide.

Group II. Athamii. Cephalothorax high, short, quadrate.

Group III. Simonellii. Cephalothorax nodose; spiders ant-like in form.

* E. Simon, Ann. Mus. Civ. di Storia Naturale di Genova, V. XX, 1884.

GROUP I. LYSSOMANII.

Quadrangle of eyes never more than one-third wider than long .... *Lyssomanes.*
Quadrangle of eyes at least twice as wide as long..... *Asamonea.*

GENUS LYSSOMANES HENTZ.

Cephalothorax moderately high, sloping downward behind and on the sides from the caput; about one-third longer than wide. General form oval. Caput occupying one-half or nearly one-half of cephalothorax.

Eyes arranged in four transverse rows of two each. Eyes of first row close together, from two to three times as large as those of second row, occupying the entire face. Second row just behind first and about as wide (sometimes a little wider or narrower). Third row composed of two very small eyes, plainly nearer the second than the fourth row; narrower than second and wider than fourth row. Eyes of fourth row about as large as those of the second and nearer together; quadrangle formed by second and fourth rows as wide as long or from one-fourth to one-third wider.

Sternum somewhat heart shaped; length and width about equal.

Coxæ separated by the width of the labium and part or all of the maxillæ.

Maxillæ slightly enlarged at extremities.

Labium about as wide as long or a little longer than wide.

Abdomen long, slender, tapering, spinnerets short.

Legs usually long and slender. Relative length variable. Long and slender femoral, tibial, metatarsal and usually patellary spines on the four pairs.

Sub-genus *Maroussa.** Second row of eyes always wider than first. Eyes of second row frequently only about one-third as large as those of first.

Sub-genus *Jelskia.* Second row of eyes not wider than first (equally wide or a little narrower). Eyes of second row relatively larger than in *Maroussa* and often placed directly above those of first row, looking forward.

SUB-GENUS MAROUSSA.†

A. Quadrangle of eyes not more than one-fourth wider than long.

Femur of the first as long as femur and patella of the second; metatarsus of the first bent..... *antillanus.* (San Domingo).

Femur of the first scarcely longer than femur of the second; metatarsus of the first not bent..... *unicolor.* (Peru).

* Russian proper name.

† All the species of the sub-genus *Maroussa* have the leg formula 1 2 3 4, excepting *modestus*, Madagascar (4 $\overline{1\ 3}$ 2), and *antillanus*, San Domingo (1 4 3 2); while in the sub-genus *Jelskia* the formula 1 2 3 4 occurs in only three species, *amazonicus*, *nigropictus* and *landus*.

LYSSOMANES ANTILLANUS N. SP.

Plate XI, figure 1.

♂. Length of cephalothorax 2.4 mm; of abdomen, 4 mm.

Legs 12.5, 9.5, 8.5, 7.4.

Cephalic and thoracic parts equally long. Quadrangle of eyes one-fourth wider than long. Eyes of first row nearly three times as large as those of the second. Clypeus one-fifth as high as anterior eyes. Falces rounded, horizontal, diverging, four or five times as long as face; fang as long as falx. Maxillæ rounded and a little enlarged at their extremities. Labium a little longer than wide, a little narrower, and blunt at the tip, one-half as long as maxillæ. Legs 1, 2, 3, 4; femur of the first as long as femur with patella of the second; metatarsus of the first elongated and curved.

Coloration (dry): Upper surface of cephalothorax light-yellowish brown, with some bright red hairs on the eye region, and a dark brown central band from the fourth row of eyes to the posterior margin. Clypeus bright red with a whitish line above the insertion of the falces. Abdomen above dark brown with a white band around base and sides. Falces dark brown, fang black. Legs, palpi, mouthparts and coxæ light brown. Sternum and venter drab, with short white hairs.

Habitat: San Domingo.

From the collection of M. Simon.

LYSSOMANES UNICOLOR TACZ. 1874.

Plate XI, figure 2; plate XII, figure 21.

Jelskia unicolor Tacz. 1874. Les Aranéides de la Guyane Française Horæ Soc. Ent. Ross., T. VIII, p. 131,

" " " 1879. Les Aranéides du Pérou, Bull de la Soc. Imp. des. Nat. de Moscou. T. LIII, 1878, No. 4, p. 373.

♂. Length of cephalothorax 2.7 mm; of abdomen 4.2 mm.

Legs 12, 10.9, 10.8, 10.7.

♀. Length of cephalothorax 3 mm; of abdomen 5.2 mm.

Legs 12, 11, 10.5, 10.5.

Cephalic and thoracic parts equally long. Quadrangle of eyes scarcely one-fourth wider than long. Eyes of first row but little more than twice as large as those of second. Second row wider in ♂ than in ♀, a little wider than the first row in both sexes. Clypeus about one-third as high as anterior eyes. Falces weak, vertical, parallel, about as long as face; fang weak. Maxillæ rounded and a little enlarged at their extremeties. Labium about as wide as long, blunt,

(♂) one-half, (♀) a little more than one-half as long as maxillæ. Coxæ of the first not so widely separated as usual, *i. e.*, by scarcely more than the width of the labium. Legs 1, $\overline{2, 3, 4}$; femur of the first but little longer than femur of the second; metatarsus of the first not curved.

Coloration (dry): ♂. Upper surface of cephalothorax pale yellow; eye-region nearly covered with bright red hairs; white hairs on the clypeus, in circles around the anterior eyes, and in patches outside the second and third rows of eyes. Upper surface of abdomen pale yellow with two divergent brown bands from base to apex, which are enlarged at three points to form as many pairs of opposed dots, one pair at each end, and one in the middle. Legs pale yellow with black spines and tips and dark brown bands at the joints. Palpus pale; bulb brown with pale tarsus projecting beyond. Falces and under surface pale pellow.

The same description answers for the female, excepting that the bands and dots on the abdomen are indistinct, and that there are no brown bands on the legs.

Habitat: French Guiana, Peru.

By the relatively larger eyes of the second row, and the relatively greater length of the quadrangle of the eyes this species approaches the sub-genus *Jelskia*.

B. Quadrangle of eyes one-third wider than long.

MALES.

1	Femur of the first as long as femur and patella of the second..	*viridis.* (South United States).
	Femur of the first not so long as femur and patella of the second	2
2	Tarsus of palpus less than twice as long as tibia.....	*bi-tæniatus* (Venezuela).
	Tarsus of palpus more than twice as long as tibia	3
3	No fringe of hairs on tibia of the first.....	*placidus.* (Mexico).
	Tibia of the first with fringe of hairs.....	4
4	Tibia of the first with fringe of hairs on proximal half of upper side and on distal half of under side; tibia of the second with fringe of hairs throughout its length on under side.....	*miniaceus.* (Rio Janeiro).
	Tibia of the first with fringe of hairs on under side nearly throughout its length; no fringe on tibia of the second.....	*austerus* (Rio Janeiro).

FEMALES.

1	Legs 4 $\overline{1\ 3}$ 2.....	*modestus.* (Madagascar).
	Legs 1 2 3 4.....	2
2	Eyes of first row three times as large as those of second; falces twice as long as face, moderately stout.....	*viridis.* (South United States).
	Eyes of first row only twice as large as those of second; falces as long as face, weak	*tristis.* (Brazil).

LYSSOMANES VIRIDIS WALCK. 1837.

Plate XI, figure 3. Plate XII, figures 6, 6a, 6b.

Altis viridis Walck. 1837. Hist. Nat. des. Insectes. T. I, p. 469.
Lyssomanes viridis Hentz. 1844. Jour. Bost. Soc. Nat. Hist., IV., pp. 386–396.
" " " 1875. Occ. Pap. Bost. Soc. Nat. Hist., II, Spiders of U. S., p. 48.

♂. Length of cephalothorax 2.5 mm; of abdomen 4.5 mm.
Legs 12, 9.5, 8.5, 8.2. Falces 2.3 mm.
♀. Length of cephalothorax 3 mm; of abdomen 5.2 mm.
Legs 10, 9, 8, 7.8. Falces 1 mm.

Cephalic part not quite so long as thoracic. Quadrangle of eyes one-third wider than long. Eyes of first row three times as large as those of second row. Clypeus one-fourth as high as anterior eyes. Falces (♂) horizontal, diverging, rounded, four times as long as face; on the distal end of each falx, on the inner edge, are two stout projections; fang as long as falx, curved. Falces (♀) rather stout, nearly vertical, twice as long as face; fang one-half as long as falx. Maxillæ rounded and a little enlarged at their extremities. Labium a little longer than wide, more than one-half as long as maxillæ, blunt; in ♂ narrow at the base. Legs 1, 2, 3, 4. Femur of the first (♂) quite, (♀) nearly equal to femur with patella of the second. Metatarsus of the first (♂) bent, with fine fringe of hairs at distal end. Spines rather long.

Coloration (under alcohol): Upper surface of cephalothorax and falces light yellow (♂) with tinge of red; a short dark median longitudinal line on anterior thoracic part. Sternum, coxæ, mouthparts and upper and under surface of abdomen pale yellow. Legs pale with slightly darker spines and black tips, (♂) tibia of the first darker toward extremity with some short dark hairs; matatarsus of the first brown at distal end with fringe of short brown hairs.

Habitat: Southern United States.

Hentz describes this species as follows: "Tender grass-green; cephalothorax with some orange-colored hairs near the eyes, and a little black line on the disk; abdomen with six or eight black dots, sometimes wanting." The green color evidently fades to a light yellow in alcohol. Hentz probably never had a mature male, as he makes no reference to the long horizontal falces.

LYSSOMANES BI-TÆNIATUS N. SP.

Plate XI, figure 4.

♂. Length of cephalothorax 2.5 mm; of abdomen 4 mm.

Legs 11.5, 9.4, 9, 8.8. Falces 1.5 mm.

Cephalic and thoracic parts equally long. Quadrangle of eyes nearly one-third wider than long. Eyes of first row about three times as large as those of second row. Clypeus one-fifth as high as anterior eyes. Falces horizontal, diverging, three times as long as face; fang bent, as long as falx. On the front face of each falx, just above the insertion of the fang, are seven or eight stout hairs which form a triangle with the apex up. Maxillæ rounded and a little enlarged at their extremities. Labium as wide as long, one-half as long as maxillæ, truncated. Legs $1, \overline{2, 3, 4}$. Femur of the first nearly as long as femur with patella of the second. Metatarsus of the first elongated, bent, with a fringe of hairs occupying distal third. Palpus with femur elongated, and patella plainly shorter than tibia. Tibia with a row of stout hairs on upper and outer side of distal half.

Coloration (under alcohol): Upper surface of cephalothorax pale yellow with a dark line around lower margin, and a central longitudinal dark line on thoracic part. Upper surface of abdomen pale yellow with two parallel longitudinal brown bands throughout its length, on which are three pairs of spots, formed by enlargements of the bands. Falces pale yellow, with an oblique band of darker reddish yellow arising at the proximal end, above, and passing downward and inward to the inner side of the insertion of the fang. Legs pale yellow with dark bands at joints, brown spines, and black tips. Palpus and entire under surface, light yellow.

Habitat: Venezuela. (Caracas).

From the collection of M. Simon.

LYSSOMANES PLACIDUS N. SP.

Plate XI, figure 5.

♂. Length of cephalothorax 2.8 mm; of abdomen 4 mm.

Legs 12, 9.3, 9, 8.8.

Cephalic and thoracic parts equally long. Quadrangle of eyes one-third wider than long. Eyes of first row more than twice as large as those of second. Clypeus nearly one-half as high as anterior eyes. Falces weak, vertical, parallel, as long as face; fang weak. Maxillæ truncated and a little enlarged at their extremities, cut obliquely on their inner edges. Labium longer than wide, rounded, slightly more than one-half as long as maxillæ. Legs $1, \overline{2, 3, 4}$; femur of the first

shorter than femur with patella of the second; metatarsus of the first long, slightly bent; tarsus of the first with fringe of hairs. The tibial and metatarsal spines are long and slender, and are arranged in inferior rows.

Coloration (dry): Upper surface of cephalothorax light brown with a dark line around the lower margin; eye-region and clypeus pale, covered with white and red hairs. Upper surface of abdomen blackish, with a white central longitudinal band extending through two-thirds of its length; this band suddenly contracts a little behind its middle point, its posterior end being thus made narrower than its anterior portion. The posterior end of the venter is blackish, the color being continuous with that of the upper surface, and extending forward in a gradually narrowing band, to about the middle; on either side of this band, and at the anterior end, the venter is white. Legs and palpi pale with dark bands and black tips, the first and second pairs of legs being darker than the third and fourth; tarsus of the first black with a fringe of black hair. Other parts all pale.

Habitat: Mexico.

LYSSOMANES MINIACEUS N. SP.

Plate XI, figure 6.

♂. Length of cephalothorax 3 mm; of abdomen 4 mm.

Legs 10.8, 8.8, 8, 7.8.

Cephalic and thoracic parts equally long. Quadrangle of eyes one-third wider than long. Eyes of the first row twice as large as those of second. Clypeus nearly one-half as high as anterior eyes. Falces weak, nearly vertical, about as long as face; fang short. Maxillæ rounded and a very little enlarged at their extremities, excavated on their inner sides for the labium. Labium a very little longer than wide, more than one-half as long as maxillæ, widest in the middle, blunt at tip. Legs stouter than is usual in this genus, 1, $\overline{2, 3, 4}$. Femur of the first but little longer than femur of the second. Fringes of hair on upper and under sides of tibia of the first, on under side of tibia of the second, and on outer distal half of femur of palpus.

Coloration (dry): Upper surface of cephalothorax pale brown with a dark rim around the lower margin. Eye region covered with bright yellowish red hairs, which surround the anterior eyes. Clypeus light brown, with lower margin black. Upper surface of abdomen dark drab, with a wide, pale central band extending through half of its length; under surface dark brown with a curved, white, longitudinal band on each side. Falces light reddish. Sternum and coxæ light red, coxæ of the first, deeper in color than the others. Mouthparts brown, tipped with pale. Legs of first pair red; of second, third and fourth pairs red mingled with white, the fourth pair being almost en-

tirely white. Palpus red, excepting proximal half of femur which is pale. Tips of legs, spines and fringes of hair on legs and palpi, black.

Habitat: South America (near Rio Janiero).

From the collection of M. Simon.

LYSSOMANES AUSTERUS N. SP.

Plate XI, figure 7. Plate XII, figure 17.

♂. Length of cephalothorax 2.7 mm., of abdomen 4.5 mm.

Legs 11.5, 9.5, 9.3, 9.3.

♀. Length of cephalothorax 2.8 mm; of abdomen 4 mm.

Legs 9, 7.8, 7.3, 6.9.

Cephalic part not quite so long as thoracic. Quadrangle of eyes one-third wider than long. Eyes of first row three times as large as those of second. Clypeus one-third as high as anterior eyes, (♂) projecting forward over the falces. Falces nearly vertical, parallel, as long as face, (♂) moderately stout, (♀) weak. Maxillæ rounded and a little enlarged at their extremities. Labium longer than wide, rounded, narrowing slightly toward its base, and a little more than one-half as long as the maxillæ. Coxæ of the first separated (♀) by a little more than width of labium ,(♂) more widely. Legs 1, 2, 3, 4; femur of the first nearly as long as femur with patella of the second; tibia of the first with a fringe of stout hairs.

Coloration (dry): ♂. Upper surface of cephalothorax light brown, pale on the anterior side; eye-region with bright red hairs. Abdomen blackish with a pale central longitudinal band above, and two white longitudinal lines on the venter. Falces brown. Sternum and coxæ pale. Mouthparts dark tipped with white. First and second pairs of legs with first three joints dark brown and the others pale; third and fourth pairs dark brown with pale rings; tarsi tipped with black. Palpus brown with proximal end of femur pale. (♀) light yellow; eye region covered with bright red hairs. Spines and tips of legs black.

Habitat: South America (near Rio Janeiro.)

From the collection of M. Simon.

LYSSOMANES MODESTUS N. SP.

Plate XII, figure 10.

♀. Length of cepalothorax 2 mm; of abdomen 3.3 mm.

Legs 7, 6.5, 6.8, 8.

Cephalic and thoracic parts equally long. Quadrangle of eyes one-third wider than long. Eyes of first row a little more than twice as large as those of second. Clypeus one-half as high as anterior eyes. Falces

weak, vertical, parallel, scarcely as long as face; fang weak. Maxillæ rounded and a little enlarged at their extremities. Labium as wide as long, rounded, almost one-half as long as maxillæ. Coxæ of the first separated by but little more than the width of the labium. Legs 4, $\overline{1, 3}$, 2; femur of the first scarcely longer than femur of the second.

Coloration (dry): Upper surface of cephalothorax, light yellow; eye-region surrounded above by a band of bright-red hairs covered in the middle with white hairs. Clypeus with thick white hairs. Abdomen above light brown or yellow, with silvery white hairs; two parallel longitudinal bands of red hairs extend throughout its length, and these are connected by transverse bands of red hairs in three places, at the anterior and posterior ends, and in the middle. Legs light yellow with brown spines and black tips. Other parts all light yellow.

Most of our specimens have all the hair rubbed off from the abdomen, which then presents a plain light colored surface with a few dark dots.

Habitat: Madagascar.

LYSSOMANES TRISTIS N. SP.

Plate XII, figure 12.

♀. Length of cephalothorax 2.5 mm; of abdomen 5 mm.

Legs 8.5, 7.4, 7, 5.

Cephalic part not quite so long as thoracic. Quadrangle of eyes one-third wider than long. Eyes of first row twice as large as those of second. Clypeus a little less than one-half as high as anterior eyes. Falces weak, vertical, about as long as face; fang short. Maxillæ rounded, and a little enlarged at their extremities, excavated on their inner sides for the labium. Labium about as wide as long, blunt, and narrowing a little at the tip, and a little more than one-half as long as maxillæ. Legs 1, $\overline{2, 3}$, 4; femur of the first shorter than femur with patella of the second.

Coloration (dry): Upper surface of cephalothorax yellowish-brown; eye-region and clypeus covered with snowy white hairs. Abdomen, above and beneath, very light brown, probably covered with white hairs, which in the specimens which we have examined are almost entirely rubbed off. Legs pale, darkening somewhat toward the proximal ends, with brown tips, and light colored spines. Other parts all pale.

Habitat: Brazil.

From the Berlin collection, through the courtesy of Dr. Ferd. Karsch.

SUB-GENUS JELSKIA.

A. Quadrangle of eyes as long as wide, or barely wider than long.

MALES.

1	Tarsus of palpus five times as long as tibia	*tenuis.* (Brazil).
	Tarsus of palpus only twice as long as tibia	2
2	Falces very long (3 mm); fang as long as falx	*jemineus.* (South America).
	Falces short; fang plainly shorter than falx	*nigropictus.* (Amazon).

FEMALES.

3	Metatarsus of the first elongated and bent	*jemineus.* (South America).
	Metatarsus of the first neither elongated nor bent	*parallelus.* (South America).

LYSSOMANES TENUIS N. SP.

Plate XI, figure 8.

♂. Length of cephalothorax 2 mm; of abdomen 2.9.

Legs 13, 9, 8, 10.

Cephalic part as long as thoracic. Quadrangle of eyes as long as wide. Eyes of first row twice as large as those of second. Second row narrower than first. Clypeus one-fifth as high as anterior eyes. Falces nearly horizontal, diverging, a little longer than face; fang as long as falx. Maxillæ rounded and slightly enlarged at their extremities, excavated for the labium. Labium as wide as long, one-half as long as maxillæ, narrowing at base, blunt at extremity. Legs 1, 4, 2, 3; femur of the first longer than femur with patella of the second; femur, tibia and metatarsus of the first, much elongated. Legs all slender. Spines growing gradually weaker from first to fourth, being scarcely more than hairs on tibia and metatarsus of the fourth. Palpus with patella and tibia more than two-thirds as long as tarsus. Spines on palpus as follows: femur, two spines at distal end, one just behind these, and a fourth in the middle; patella, one long spine at distal end; tibia, one in the middle and one at distal end; tarsus, two spines, or long hairs, on dorsum of enlarged part, one placed behind the other.

Coloration (dry): Upper surface of cephalothorax, clypeus and abdomen black with thin, white hairs, the abdomen having a faintly indicated transverse band of a lighter shade behind the middle. Falces and palpi dark brown. Sternum, coxæ and mouthparts, light brown. Legs light reddish brown, with brown spines and black tips.

Habitat: South America (near Rio Janiero.)

From the collection of M. Simon.

See remarks under *Jelskia velox.*

LYSSOMANES JEMINEUS N. SP.

Plate XI, figure 9. Plate XII, figure 14.

♂. Length of cephalothorax 2.5 mm; of abdomen 5 mm.

Legs 16.3, 12, 11.4, 11.8. Falces 3 mm.

♀. Length of cephalothorax 3 mm; of abdomen 5 mm. (Legs too badly broken to be measured.)

Cephalic part not quite so long as thoracic. Quadrangle of eyes about one-fifth wider than long. Eyes of first row three times as large as those of second. Second row slightly narrower than first. Clypeus nearly one-third as high as anterior eyes. Falces (♂) stout, horizontal, three times as long as face, diverging; fang as long as falx, with a double curve; (♀) stout, nearly vertical, about twice as long as face, bulging in front, nearly parallel; fang short. Maxillæ blunt, and a little enlarged at their extremities. Labium longer than wide, a little more than one-half as long as maxillæ, widest in the middle. Legs 1, 2, $\overline{4, 3}$; (♂) femur, tibia and metatarsus of the first all much elongated, metatarsus curved; a wide fringe of hairs on each side of tibia and metatarsus of the first, less marked on tibia of the second, and much less on metatarsus of the second; (♀) metatarsus of the first long, curved, without hairs, but with longer and stouter spines than ♂. (♂) Palpus with femur as long as falx; patella but little shorter than tibia; patella and tibia two-thirds as long as tarsus; a bunch of hairs on outer side of distal half of tibia; two spines at distal end of femur and one at extremity of patella.

Coloration (under alcohol): Cephalothorax, reddish yellow; cephalic part with a band of yellowish white hairs on each side below the eyes; a large bright red spot behind the eyes of the fourth row which extends forward between them; and a red spot on the outer side of each anterior eye; eyes of third row surrounded by reddish hairs. Thoracic part with a dark brown central longitudinal band extending from just behind fourth row of eyes to posterior margin. Falces reddish yellow. Mouth parts, sternum and coxæ pale yellow; abdomen above, mottled brown; sides pale yellow; venter with dark brown, median, longitudinal band. Legs pale yellow or light brown; (♂) black fringes of hair on tibiae and metatarsi of the first and second. (♂) Palpus pale yellow excepting tibia and tarsus which are brown.

Habitat: South America.

From the collection of M. Simon.

The male of this species is easily distinguished by its elongated falces, and by the double fringes of hair on the first and second pairs of legs.

LYSSOMANES NIGROPICTUS N. SP.

Plate XI, figure 10.

♂. Length of cephalothorax 2.8 mm; of abdomen 4 mm.

Legs 12.5, 11.5, 11.3, 10.8.

Cephalic part as long as thoracic. Quadrangle of eyes scarcely wider than long. Eyes of first row twice as large as those of second row. First and second rows equally wide. Clypeus nearly one-half as high as anterior eyes. Falces weak, parallel, vertical, as long as face; fang weak. Maxillæ rounded and slightly enlarged at their extremities, excavated on their inner sides for labium. Labium longer than wide, about one-half as long as maxillæ, blunt at tip, widest in the middle, and narrowing toward both ends. Coxæ separated by but little more than width of labium. Legs 1, 2, $\overline{3, 4}$. Femur of the first scarcely longer than femur of the second. Palpus with patella and tibia three-fourths as long as tarsus. Spines on palpus as follows: femur, two on dorsum at distal end; patella, one long spine at extremity; tibia, one behind middle on inner side, and one at distal end; tarsus, two long spines on dorsum of enlarged part, placed side by side.

Coloration (under alcohol): Upper surface of cephalothorax with eye-region white, and the remainder very light brown; there is a black line around the lower margin and a central dark brown band from the fourth row of eyes to the posterior edge. Upper surface of abdomen white with four pairs of brown spots; the first pair is on the anterior face of the abdomen and is not plainly visible from above; the third pair is just behind the middle point of the dorsum; the fourth pair is just in front of the white spinnerets, and the two spots are connected by a brown band. Legs white with brown rings and spines and black tips. Palpus white with a dark line on each side of the femur, and having the bulb light brown, and some dark hairs at the extremity of the tarsus. Other parts all white.

Habitat: South America (Amazon).

From the collection of M. Simon:

The tarsus of the palpus of this species has an arrangement of the spines which is only duplicated in *Jelskia velox*, the palpus differing from that of this species in having no fringes of hair on the patella and tibia. It has, moreover, the first two pairs of legs more nearly equal in length than any species excepting *Jelskia robusta*, from which it is quickly distinguished by its much lighter color.

LYSSOMANES PARALLELUS. N. SP.

Plate XII, figure 15.

♀. Length of cephalothorax 1.9; of abdomen 3 mm.

Legs 9, 7, 7, —. (Fourth leg missing.)

Cephalic part as long as thoracic. Quadrangle of eyes scarcely wider than long. Eyes of first row a little more than twice as large as those of second. Second row narrower than first. Clypeus scarcely one-fifth as high as anterior eyes. Falces moderately stout, somewhat inclined forward, diverging, as long as face. Maxillæ excavated on inner sides for labium; extremities rounded, near together, but little enlarged. Labium but little longer than wide, truncated, a little more than one-half as long as labium. Legs 1, 2, 3, —; femur of the first as long as femur with patella of the second.

Coloration (dry): Eye region covered with mixed red and white hairs; upper surface of thoracic part brown, glabrous, with a pale transverse band just behind the fourth row of eyes; sides pale excepting lower margin, which is brown. Clypeus covered with white hairs. Abdomen pale with two longitudinal brown bands originating separately at the base and meeting at the apex. Falx yellowish brown with a fringe of red hairs at extremity. Mouthparts light brown. Sternum, coxæ, and venter pale yellowish. Legs pale; first leg and femur of second with a dark line on each side; spines brown, tips black. Palpus pale excepting tarsus, which is light brown.

Habitat: South America.

From the collection of M. Simon.

B. Quadrangle of eyes from one-fifth to one-third wider than long.

MALES.

1	Tarsus of palpus five times as long as tibia	*velox.* (Brazil).
	Tarsus of palpus only twice as long as tibia	2
2	Femur of the first as long as femur and patella and one-half tibia of the second	*longipes.* (French Guiana).
	Femur of the first scarcely longer than femur of the second	3
3	Legs 1 $\overline{3\ 4\ 2}$	*robustus.* (Peru).
	Legs 1 2 3 4	*amazonicus.* (Amazon).

FEMALES.

1	Eyes of first row three times as large as those of second; eyes of fourth row a little smaller than those of second	*amazonicus.* (Amazon).
	Eyes of first row only twice as large as those of second; eyes of fourth row as large as those of second	*blandus.* (Guatemala).

LYSSOMANES VELOX N. SP.

Plate XI, figure 11.

♂. Length of cephalothorax 2.7 mm.; of abdomen 4 mm.

Legs 14, 13.2, 15, 15.5.

Cephalic part plainly shorter than thoracic. Quadrangle of eyes a little more than one-third wider than long. Eyes of first row three times as large as those of second. First and second rows equally wide. Clypeus one-fourth as high as anterior eyes. Falces weak, nearly vertical, parallel, a little longer than the face; fang weak. Maxillæ slightly enlarged beyond the middle, rather pointed, very little excavated on their inner edges. Labium a little longer than wide, one-half as long as maxillæ, a little narrower, and blunt at tip. Legs long and slender, 4, 3, 1, 2; femur of the first about as long as femur of the second. Palpus with patella and tibia one-half as long as tarsus; patella and tibia with fringe of hairs on outer edge; those on tibia pointing downward and outward, those on patella on a higher plane, and pointing forward. Spines on palpus as follows: femur, one spine at distal end, another just behind this one, and a third about in the middle of the joint; patella, one spine at distal end, in the middle; tibia, one at distal end and one in the middle on the outer edge; tarsus two long spines on the dorsum of the enlarged part, placed side by side.

Coloration (under alcohol): Inter-ocular region pale, almost white; thoracic part and sides brown, growing much darker toward lower margin. Clypeus brown with a black line above falces. Abdomen, above, with sides white, and a large white spot at anterior end which contracts behind to form a long point; dorsum occupied by a wide brown band which bifurcates in front to surround the white spot. Falces brown with white extremities. Mouthparts dark brown. Coxæ of the first brown; other coxæ, and sternum, white. Venter pale, excepting at posterior end where it is brown. Legs with upper faces of femora and tarsi pale; otherwise brown. Palpus dark brown.

Habitat: Brazil.

From the collection of M. Simon.

This species and *Jelskia tenuis* are easily distinguished from other members of this genus by their dark color and elongated legs; while *velox* is distinguished from *tenuis* by the hairs on the patella and tibia of the palpus, and by the position of the spines on the tarsus of the palpus, these being placed side by side in *velox* and one behind the other in *tenuis*.

LYSSOMANES LONGIPES TACZ. 1874.

Plate XI, figure 12.

Jelskia longipes Tacz., 1874. Les Aranèides de la Guyane française, Horae Soc. Entomol. Ross., T. VIII, p. 32–132.

♂. Length of cephalothorax 2 mm; of abdomen 3.2 mm.

Legs 12.4, 8.3, 7.7, 8.

Cephalic part as long as thoracic. Quadrangle of eyes one-fifth wider than long. Eyes of first row a little more than twice as large as those of second. Second row narrower than first. Clypeus about one fifth as high as anterior eyes. Falces very weak, vertical, parallel, as long as face; fang short. Maxillæ rounded, and a very little enlarged at their extremities, excavated on inner sides for labium. Labium as wide as long, one-half as long as maxillæ, blunt. Legs 1, 2, 4, 3; femur of the first very long, equalling femur with patella and half tibia of the second. Palpus with patella and tibia about equal in length; patella and tibia three-fourths as long as tarsus, spines on palpus as follows: Femur, two at distal end, and one in the middle of the dorsum, all short; patella, one at extremity; tibia, one long hair in the middle, and one at extremity; tarsus, one long hair on dorsum of enlarged part.

Coloration (under alcohol): Upper surface of cephalothorax deep reddish yellow, with a narrow black line around lower edge and another on the central thoracic region; eyes, as usual, on black spots. Abdomen above, with a blackish region at the extremity in front of which is a white band; the remainder of the dorsum is blackish excepting three white spots, one elongated, large, one on the anterior central part, and two smaller, which come off obliquely from the posterior corners of the first one. Spinnerets white. Ventral surface white excepting at the extremity where it is blackish. Sternum, mouthparts, and falces yellow. Legs light yellow with brownish spines and tips. Palpus pale with the bulb reddish brown.

When dry, the eye-region is seen to be covered with white hairs. The abdomen is also thinly covered with short white hairs.

Habitat: French Guiana.

From the collection of Dr. Taczanowski.

This species is distinguished by the great relative length of the first pair of legs, and especially by the elongation of the femora of that pair.

LYSSOMANES ROBUSTUS TACZ. 1879.

Plate XI, figure 13. Plate XII, figure 7.

Jelskia robusta Tacz. Les Aranéides du Pérou. Bull. de la Soc. Imp. des Nat. de Moscou, T. L III, 1878, No. 4, p. 373.

♂. Length of cephalothorax 2.3 mm; of abdomen 3 mm.

Legs 9.2, 8.6, 8.8, 8.7.

Cephalic part a little shorter than thoracic. Quadrangle of eyes nearly one-fourth wider than long. Eyes of first row twice as large as those of second. Eyes of second row placed directly above those of first, forming a row equally wide, looking forward. Clypeus only a line. Falces very weak, vertical, parallel, as long as face; fang very short. Maxillae and labium unusually short. Maxillæ rounded and a little enlarged at their extremities, which are quite close together, excavated on their inner sides for the labium. Labium a little longer than wide, rounded at tip, one-half as long as maxillæ. Legs 1, 3, 4, 2; femur of the first not quite so long as femur with patella of the second. Palpus with patella and tibia equally long; patella and tibia two-thirds as long as tarsus. Tibia with a stout fringe of hairs on the outer edge. Tarsus with one spine on dorsum of enlarged part behind middle.

Coloration (dry): Upper surface of cephalothorax jet black, with two indistinct brownish spots on thoracic part, and a few long white hairs on eye-region. Clypeus black. Abdomen above, black, thinly covered with whitish hairs, and having two indistinct brownish spots behind the middle. Falces black with extremities and fangs pale yellow. Mouthparts black; sternum black with a large pale yellow spot in center. Venter pale yellowish, excepting the anterior and posterior ends, which are pale. Legs light yellow, excepting tarsus of the first, and tips of other legs which are black. Palpus black, except that part of the tarsus which projects beyond the bulb which is pale yellow.

Habitat: Peru.

From the collection of Dr. Taczanowski.

The jet black body and pale legs of this species quickly distinguish it from all members of this group.

LYSSOMANES AMAZONICUS N. SP.

Plate XII, figures 1, 16.

♂. Length of cephalothorax 2.5 mm; of abdomen 4.4 mm.
Legs 12.5, 11, 10.8, 10.8.
♀. Length of cephalothorax 2.5 mm; of abdomen 5 mm.
Legs 11.3, 10, 9.4, 9.2.

Cephalic part (♂) as long (♀) not quite so long as thoracic. Quadrangle of eyes one-fifth wider than long. Eyes of first row three times as large as those of second. Second and first rows equally wide. Clypeus one-third as high as anterior eyes. Falces rather stout, diverging, not quite vertical, one-third longer than face; on the front of each falx just above insertion of fang, is a line of three stout hairs. Maxillæ rounded and a little enlarged at their extremities. Labium longer than wide, blunt and slightly narrower at extremity, and a little more than one-half as long as maxillæ. Legs 1, 2, $\overline{3, 4}$; femur of the first not so long as femur with patella of the second. (♂) Palpus with tibia plainly longer than patella; patella and tibia plainly less than one-half as long as tarsus. Femur with two spines at distal end and one in the middle; patella with one long hair at extremity; tibia with one stout hair at distal end on inner side.

Coloration (under alcohol): ♂. Light yellow. Eye-region covered with white hairs; there is an abbreviated central longitudinal black line on the thoracic region, and a black line around the lower margin. The abdomen has two longitudinal brown bands throughout its length which are enlarged at the middle point and again at the posterior end to form two pairs of spots. The spinnerets are brown. The legs grow darker toward their extremities and are tipped with black.

♀. Yellowish white. Cephalothorax like ♂ excepting that there is no dark marginal line. Abdomen with two pairs of brown spots, and with the spinnerets pale. The color is paler and the marks less distinct than in the ♂.

Habitat: South America (Amazon).

From the collection of M. Simon.

The male of this species differs from all others in the greater relative length of the tarsus of the palpus, the tarsus being more than twice as long as the patella and tibia together.

LYSSOMANES BLANDUS N. SP.

Plate XII, figure 13.

♀. Length of cephalothorax 2.8 mm.; of abdomen 4.6 mm.

Legs 12.3, 10, 9.6, 9.6.

Cephalic part as long as thoracic. Quadrangle of eyes one-fourth wider than long. Eyes of first row twice as large as those of second. First and second rows equally wide. Clypeus one-half as high as anterior eyes. Falces robust, nearly horizontal, one and one-half times as long as face. Maxillæ a little enlarged and rounded at their extremities, slightly excavated on their inner sides. Labium longer than wide, a little more than one-half as long as maxillæ, widest in the middle, blunt at extremity. Legs 1, $\overline{2, 3}$, $\overline{4}$; femur of the first shorter than femur with patella of the second.

Coloration (under alcohol): Cephalothorax light yellow; eye region surrounded with red and white hairs; anterior thoracic part with a dark central longitudinal line. Abdomen white with scattered light brown hairs; on the posterior part of the dorsum are two abbreviated, longitudinal, light brown bands, and there are some irregular, light brown spots on the anterior part. Falces, legs, palpi, mouthparts and sternum all pale yellow.

Habitat: Guatemala.

GENUS ASAMONEA (CAMBRIDGE) SIMON.

Cephalothorax low; cephalic plate usually but little higher than thorax, occupying a little more than one-third of the cephalothorax.

Eyes in four transverse rows of two each. Eyes of first row close together, from two and one-half to three times as large as those of second row (relatively larger than in Lyssomanes), occupying the entire face. Second row of eyes wider than first. Eyes of third row much nearer the second than the fourth and much nearer together than those of second row; third row narrower than second, and sometimes wider, sometimes narrower than fourth. Eyes of fourth row about as large as those of second and nearer together. Quadrangle formed by second and fourth rows, at least twice as wide as long.

Sternum little, if any, longer than wide, truncated in front.

Coxæ separated by the width of the labium and part or all of that of the maxillæ.

Labium at least as wide as long.

Abdomen long, slender, tapering.

Legs slender; (♂) 1 4 3 2 or 1 4 2 3; (♀) fourth leg longest, others nearly equal. Femoral, tibial, metatarsal and sometimes patellary spines on the four pairs.

A. Eyes of third row but little smaller than those of the fourth.

MALES.

General color light; integument covered with silvery hairs	*puella.* (South Africa).
General color dark	*tenuipes.* (Ceylon.)

FEMALES.

1	First and third legs equal	*tenuipes.* (Ceylon).
	First and third legs not equal	2
2	Legs 4 1 2 3	*puella.* (South Africa).
	Legs not 4 1 2 3	3
3	Legs 4 3 $\overline{2\ 1}$	*punctata.* (Madagascar).
	Legs 4 $\overline{2\ 3}$ 1	*ornatissima.* (Madagascar).

ASAMONEA PUELLA SIMON. 1885.

Asamonea puella Simon. Bull. de la Soc. Zool. 1885, T. X. p. 27.

Having no mature specimen of this species we translate the following description from Simon:

♂. Length 6 mm. Cephalothorax yellowish testaceous narrowly bordered with brownish, with the cephalic part covered with yellow hair, and having on each side a large black three-lobed spot which surrounds the eyes; the thoracic part, above, with two lines covered with thin red hairs which come together posteriorly. Clypeus very high, smooth behind the falces, above the eyes densely pubescent, in the middle silvery, on each side reddish. Abdomen steeply elongate, covered with hairs which are whitish testaceous and silvery white, adorned above with two lines, prettily interrupted with red. Spinnerets testaceous, upper ones brownish. Falces yellow testaceous, cut transversely by a black band in front. Sternum testaceous. Legs testaceous, femora with brownish lines below; tibia of fourth from base to apex, minutely dotted with brown; abundantly armed with long and delicate spines. Palpi testaceous with the stout femur armed below, back of the middle, with an obtuse tubercle; patella short; tibia not longer than patella, slightly thicker on the outside and enlarged into a keel-shaped laminate apophysis which is a little thickened and obtuse in the middle and very sharply prolonged above; the large tarsus longer than the femur and much thicker, convex and attenuated longitudinally with a large convex bulb.

♀. Length 7 mm. Cephalothorax with no lines on thoracic part. Clypeus, behind falces smooth, above eyes covered all over with silvery hair. Falces and legs uniform yellow testaceous without lines or spots. Region of epigynum, anteriorly, with a transverse pit obtusely triangular and much broader than long; posteriorily, a shining reddish transverse spot.

ASAMONEA TENUIPES CAMB. 1869.

Plate XII, figures 5, 19, 19a, 19b.

LYSSOMANES tenuipes Camb., Ann. and Mag. Nat. Hist. S. 4, vol. 3, p, 65.

♂. Length of cephalothorax 1.5 mm; of abdomen 2 mm.

Legs 6, 5, 5, 5.3.

♀. Length of cephalothorax 1.7 mm; of abdomen 3 mm.

Legs 5.5, —, 5.5, —. (Second and fourth wanting.)

Cephalic part scarcely more than one-half as long as thoracic, in ♂ with front and sides projecting like carapace of turtle. Quadrangle of eyes twice as wide as long. Eyes of first row two and one-half times as large as those of second row. Clypeus about one-half as high as anterior eyes. Falces very weak, ♂ inclined backward, ♀ vertical, ♂ scarcely as long as face, almost quadrate, ♀ as long as face; fang very weak. Maxillæ short, truncated, ♂ a little narrower, ♀ a little wider at their extremities. Labium wider than long, wider in ♂ than in ♀, ♂ one-third, ♀ a little less than one-half as long as maxillæ, blunt at extremity. Legs, ♂ 1, $\overline{4, 3, 2}$; ♀ first and third equal. Coxæ of the first separated by the width of maxillæ and labium. Femur of the first plainly shorter than femur with patella of the second. Superior spinnerets elongated, in ♂, curved upward.

Coloration (dry): ♂. Cephalothorax dark brown, covered with whitish iridescent scales; a pale central band extends from the anterior eyes to the posterior border, and from this, curved white bands extend around the outer sides of the eye-region; the anterior part of the eye-region is covered with long white hairs. Clypeus covered with highly iridescent scales. Palpi, dark brown. Sternum and coxæ, pale. Abdomen, above and below, dark brown, shading to blackish on the sides, with a wide irregular pale ring near the posterior end: apex and curved spinnerets jet black; the whole abdomen is thinly covered with iridescent scales like those on the cephalothorax. Legs pale yellow; those of the first and second pairs have three black spots on the posterior side, one at the distal end of the femur, one at the proximal and one at the distal end of the patella; the tips of all the legs are black. Spines yellow.

♀. Light yellow with thick snowy white hairs on eye region and clypeus. Legs tipped with black.

Habitat: Ceylon.

ASAMONEA PUNCTATA N. SP.

Plate 12, figure 20.

♀. Length of cephalothorax 2.8 mm; of abdomen 5 mm.

Legs 8.7, 9, 9.5, 10.5.

We have also an immature ♂ of this species.

Cephalic part a little more than one-half as long as thoracic. Quadrangle of eyes more than twice as wide as long. Eyes of first row three times as large as those of second row. Clypeus fully one-half as high as anterior eyes. Falces weak, vertical, parallel, as long as face; fang weak. Maxillæ rounded, a little enlarged at their extremities. Labium rounded, ♂ wider than long, ♀ as wide as long; less than one-half as long as maxillæ. Legs 4, 3, $\overline{2, 1}$; femur of the first shorter than femur of the second. Spines unusually long and stout.

Coloration (under alcohol): ♀. Pale yellow, with an indistinct dark median line on the thoracic part of the cephalothorax, and three equi-distant pairs of dark brown dots on the abdomen arranged in two lines of three dots each, the posterior pair of dots being only a little behind the middle of the abdomen. The tips of the legs are black, but the spines are light colored. When the spider is dried a small tuft of black hairs becomes visible at the anterior end of the abdomen. ♂. Upper surface of cephalothorax light brown, excepting on eye-region and anterior thoracic part, where it is pale yellow; on each side of the posterior thoracic part are two dark brown dots. Abdomen with four pairs of dark brown dots at equal distances between the two ends, the first three pairs converging toward the posterior end, the two dots of the fourth pair being placed further apart than any of the others. Probably a fourth pair of dots has been effaced from the abdomen of our female specimen.

Habitat: Madagascar.

ASAMONEA ORNATISSIMA N. SP.

Plate XII, figure 22.

♀. Length of cephalothorax 2 mm; of abdomen 3 mm.

Legs 6.2, 6.6, 6.4, 7.

Cephalic part a little more than one-half as long as thoracic. Quadrangle of eyes twice as wide as long. Eyes of first row about two and one-half times as large as those of second row. Clypeus nearly one-third as high as anterior eyes. Falces weak, parallel, vertical, as long as the face, fang weak. Maxillæ rounded and very little enlarged at their extremities. Labium rounded, wider than long, less than one-half as long as maxillæ. Legs 4, $\overline{2, 3}$, 1; femur of the first about as long as femur of the second. Spines growing more slender from the first leg to the fourth.

Coloration (dry): Eye region covered with hairs of a rich brownish red color, with a wide central band of silver hairs extending between the eyes of the third row; thoracic part pale, without hairs. Clypeus with a band of silver hairs. Falces, and entire under side, pale yellow. Upper surface of abdomen covered with hairs of a rich brownish red, encircled by a band of silvery hairs, and having three spots of silvery hairs on the dorsum, the anterior one being the smallest, and the second and third broader. Legs pale, with light brown spines and black tips.

Habitat: Madagascar.

B. Eyes of third row much smaller than those of fourth (not more than one-third as large.)

Under this head we have only two individuals of different sexes. The male is *gracilis*, French Guiana, and the female *flava*, Central America.

ASAMONEA GRACILIS TACZ. 1875.

Plate XII, figure 2.

Jelskia gracilis Tacz., Les Aranéides de Guyane française, Horae Soc. Ent. Ross., T. VIII, pp. 32–132.

♂. Length of cephalothorax 1.8 mm.; of abdomen 4 mm.

Legs 11, 9, 10.8, 10.4.

Cephalic part not quite so long as thoracic. Quadrangle of eyes more than twice as wide as long. Eyes of the first row three times as large as those of second row, projecting. Clypeus nearly one-half as high as anterior eyes. Falces very weak, vertical, as long as face; fang weak. Maxillæ rounded and a little enlarged at their extremities, slightly inclined toward labium. Labium as wide as long, about one-half as long as maxillæ. Maxilliæ and labium unusually short. Legs 1, 4, 3, 2, very long and fine. Coxæ of the first more widely separated than usual — by fully the width of maxillæ and labium. Femur of the first about as long as femur with patella of the second.

Coloration: Cephalothorax and abdomen, both above and beneath, polished black, with bluish iridescent reflections. Legs very pale yellow with pale spines and hairs; on the upper surface of the first leg a black line begins on the trochanter and extends throughout half the length of the femur; there is a similar line on the upper surface of the second leg, but here it is much shorter and finer. Falces pale yellow with a black spot on the anterior face of each. Mouthparts pale yellow. Palpus black excepting the tarsus, which is light reddish yellow.

Habitat: French Guiana.

From the collection of Dr. Taczanowski.

ASAMONEA FLAVA N. SP.

Plate XII, figure 18.

♀. Length of cephalothorax 1.8 mm; of abdomen 3.8 mm.

Legs 11.8, 10.8, 11.6, 13.

Cephalic part a little more than one-half as long as thoracic. Quadrangle of eyes twice as wide as long. Eyes of first row two and one-half times as large as those of second row. Clypeus one-third as high as anterior eyes. Falces weak, shorter than face, slightly inclined backward. Maxillæ truncated, and a little enlarged at their extremities. Labium a little wider than long, less than one-half as long as maxillæ, rounded. Legs 4, 1, 3, 2. Femur of the first scarcely longer than femur of the second. Spines very few in number, and extremely weak, scarcely more than hairs. The abdomen, which is somewhat injured, seems to have been cylindrical in shape and truncated behind. Superior spinnerets not so much elongated as is usual in this genus.

Coloration (under alcohol): Light yellow; on all the legs the tibial joints have two dark brown spots at each end; the metatarsi have two brown spots at the proximal end and the metatarsus of the first has one brown spot at the distal end; the tarsi of all the legs have the distal fifth dark brown. Spines matching the legs in color.

Habitat: Central America.

LYSSOMANES PALLENS BLACKWALL. 1887.

Lyssomanes pallens, Blackwall, Proc. Royal Irish Acad., 1877, Vol. III, Ser. 2, p. 6.

Having no specimen of this species, we are unable to determine its genus, although, to judge from the drawings, it belongs to the second division of *Asamonea.* We quote the whole description as given by Blackwall:

"Length of an immature male (not including the spinners), one-fifth of an inch; length of the cepholothorax, one-sixteenth; breadth, one-sixteenth; breadth of the abdomen, one-twentieth; length of a posterior leg, one-fourth; length of an anterior leg, five-twenty-fourths. The color of this spider is white tinged with yellow, particularly on the sides and base of the cephalothorax. The eyes are disposed on the anterior part of the cephalothorax; two, which are situated in front, are much the largest, and are prominent, pellucid, and almost in contact; on each side of the upper part of the cephalic region these eyes are placed in the form of an irregular triangle, on small tubercles seated on confluent black spots, the intermediate eye, constituting the vertex of an obtuse angle, being the smallest of the eight. The cephalothorax is somewhat quadrate, convex, glossy, slightly

rounded on the sides and at the base, and moderately elevated in the cephalic region. The falces are small, sub-conical, and inclined toward the sternum, which is broad, convex, and heart-shaped; the maxillæ are short, rounded at the extremity, and inclined toward the lip, which is somewhat quadrate, being broader at the base than at the apex. The legs are slender, and provided with hairs and long spines, two parallel rows of the latter extending along the inferior surface of the tibia and metatarsus of the first and second pairs; each tarsus is terminated by two minute, curved claws, below which there is a small black scopula. The abdomen is long, sub-cylindrical, and has a few short, pale hairs distributed over its surface. The superior spinners are the longest, and their terminal joint, which is pointed, has the spinning-tubes arranged on its inferior surface. The palpi of the specimen from which the description was made were very tumid, but the palpal organs were not developed, indicating that it probably had to undergo its final change of integument before it arrived at maturity; the radial was stronger than the cubital joint, and prominent in front."

GROUP II. ATHAMII.

GENUS ATHAMAS CAMBRIDGE.

Cephalothorax high, short, quadrate, very convex above, sloping steeply behind and on the sides. Caput occupying at least one-half of cephalothorax. Eyes arranged in four transverse rows of two each. Eyes of first row large and close together. Eyes of second row two-thirds as large as those of first, forming a wider row. Eyes of third row half way between second and fourth rows, and about one-third as large as those of fourth row. Eyes of fourth row smaller than those of second and nearer together. Quadrangle formed by second and fourth rows as long as wide. Labium about as wide as long.

ATHAMAS WHITMEEI CAMBRIDGE. 1887.

Plate XII, figures 3, 11.

Athamas whitmeei Camb., Proc. Zool. Soc. of London, 1877, p. 576.

♂. Length of cephalothorax 1.6 mm; of abdomen 1.4 mm.

♀. Length of cephalothorax 1.25 mm; of abdomen, 1.75 mm.*

Legs 3.5, 2.5, 2.5, 3.

♂. Cephalic part a little longer than thoracic. Clypeus one-half as high as anterior eyes. Falces vertical, short. Maxillæ rounded and enlarged at extremities. Labium as wide as long, one-third as long as maxillæ. Sternum heart-shaped. Legs rather long and slender, those of the first pair stoutest and furnished with strong spines; relative length

* These are the measurements given by Koch. We have no female of this species.

1, 4, 3, 2. Abdomen small and short, slanting from the anterior part to the spinnerets.

Coloration: As our specimen is considerably rubbed we quote the color description given by Cambridge. "The *cephalothorax* of this very pretty and distinct spider, is of a yellow brown color, with a large pale patch on each side of the hinder extremity, and the ocular area black, thinly clothed with short white hairs, and shining, in some lights, with a strong, metallic, dark violet hue; a pale stripe densely clothed with bright white squamose hairs runs through the middle of the hinder half of the ocular area to the beginning of the posterior slope; there is also a spot of similar hairs on each side towards the hinder part, and another on each side near the hinder part of the ocular orea, just below the eyes of the third row. * * * The legs are yellow, the femora and the two other basal joints of the first pair being much stronger than the rest, and brownish black on each side. This, however, is apparently not a constant character; or at any rate it does not always exist at the first coming of the spider to maturity, but probably is acquired later; for in one of the examples before me the first pair are of the same color as the rest, and the femora of only ordinary comparative strength, and the legs themselves shorter and weaker. * * * The *palpi* are pale yellow. * * * The *falces* * * * are of a brownish yellow color with a broad rather oblique dark yellow-brown longitudinal stripe on the fore side. The *maxillæ* are yellow-brown, paler at their extremities. The *labium* is also yellow-brown, palest at the apex. The *sternum* is * * of a pale yellow color. The *abdomen* is of a palish yellow hue; on the fore half of the upper side a clearer yellow elongate-oblong central marking is indicated by a dark-brown dentated marginal line, and terminates posteriorly with a short transverse curved dark-brown stripe, behind which, again, are two longitudinal curved dark-brown markings inclosing a circular area covered densely with white squamose hairs which extends forward also to the transverse stripe above described. The sides are marked with a few dark-brown spots and markings; and on each side of the fore extremity of the oblong central marking is a large patch of white squamose hair. In front, below the fore margin, are some coarse, bristly, black, upturned hairs. The spinners are of a blackish hue, tipped with pale yellowish. * * * There is evidently some variety in the abdominal markings of this species, since in the other example before noted the upper side of the abdomen is generally suffused with dark blackish brown, showing faintly the longitudinal oblong central, yellowish marking on the fore part; the posterior and two anterior large patches of white squamose hairs, however, are even more conspicuous in this than in the other example."

As we have no female of this species we translate the description given by L. Koch, Arachniden Australiens, p. 1076, T. xciv.

♀. The cephalothorax is brownish with a narrow, black marginal band which is broadened in some places and a brownish, interrupted longitudinal stripe on the lateral declivity; the space between the eyes black with faint, blue iridescence. A median longitudinal stripe composed of brilliant yellow hairs begins on the posterior declivity and extends to the front row of eyes; the remaining hair of the cephalothorax is white mixed with pale yellow. The hair-rings around the eyes of the first and second rows orange-yellow and white, those of the first row above and below orange-yellow, without and within white. Falces dark brown; maxillæ, labium and sternum dirty brownish-yellow. Palpi and legs pale yellow; femur of the palpus with a black longitudinal stripe before and behind. Femur of the first with a black longitudinal stripe in front, and two black spots behind; femur of the second with two black spots in front and behind; femora of the third and fourth with a black ring on the basal half, and a small black spot on the terminal half before and behind. Patellæ with a black spot before and behind. The tibiæ and metatarsi have a black ring at the base and the tarsi are suffused with black at the base. Abdomen black above, with white and pale yellow hairs; from the base to a point in front of the middle runs a longitudinal band covered with deep yellow hairs, back of this, and again just in front of the spinnerets, a long spot covered with similar hair; specimens in alcohol show also the following markings which almost disappear completely in the dry animal; from the end of the longitudinal band above mentioned two undulating pale bands run first to the sides and thence in an arc back to the base, enclosing a space which is covered with pale reticulating veinlets; the posterior half of the upper surface is marked with small blue spots and streaks; the spinnerets brownish-yellow suffused with black.

Cephalothorax about one-sixth longer than broad, considerably longer than patella and tibia of the fourth, high, abrupt on the posterior edge, falling almost perpendicularly, faintly convex on the lateral perpendicular declivity, above, only slightly arched as far as the third row of eyes, but from these strongly convex, dull, covered with short hairs; the median, longitudinal stripe with hair-shaped scales; lateral margin with long black bristles which project outward; one very long anteriorly directed bristle between the eyes to the first row; clypeus as high as the radius of an eye of the first row. Eyes in four rows; quadrangle of the eyes longer than broad, narrowed behind; eyes of the fourth row as far again from the lateral borders as from each other, overhung by the lateral walls of the cephalothorax.* Eyes of the first row very large, close together and abutting on those of the second row; eyes of the second row placed above and slightly

* ". . . von der Seitenwand des Cephalothorax überragt."

projecting over those of the first, with their outer peripheries distant from one another by the diameter of one of the eyes of the first row. Eyes of the third row nearer to those of the second than to those of the fourth; those of the fourth smaller than those of the second row. Falces only a little longer than the breadth at the base, very glistening, smooth, slightly convex anteriorly, diverging on the inner side from the base. Maxillæ with outer and anterior margins straight, and inner margins also straight as far as the labium; the inner corners, consequently rather rectangular; the maxillæ are excavated along the labium; labium very short, broader than long, rounded anteriorly. Sternum cordate, slightly convex, dull, sparsely overgrown with projecting, long, yellowish hairs. Abdomen only slightly longer than broad, truncate in front, strongly convex laterally, acuminate toward the spinnerets, dull, covered with short adpressed and longer projecting hairs in many layers; the deep yellow markings formed by hair like scales. Legs short; femora convex above, underneath overgrown with long projecting hairs, with two spines above, those of the first pair with one spine above at the end. Tibiæ and metatarsi underneath beset with long spines. Spines of the patellæ, tibiæ and metatarsi of the third and fourth short. On tibiæ and metatarsi of the third and fourth above, long projecting hairs. Patella and tibia of the third as long as patella and tibia of the fourth; metatarsus and tarsus of the fourth longer than patella and tibia of the fourth.

Habitat: Tahiti, Upolu, Samoa.

GENUS EPEUS* PECKHAM.

1876. Evenus Simon, Ann. Soc. Entomol. de France (5), pp. 58–59.

1885. Epeus Peckham, Genera of Fam. Attidæ, p. 334.

Cephalothorax rather elongated; thoracic part scarcely the longer, sensibly dilated and rounded; cephalic part plane, elevated behind, inclined in front, longer than wide; superciliary projections pronounced. Median anterior eyes very large, almost touching, occupying the entire width of the face; the lateral eyes much smaller, separated, placed further back, forming a second line. Dorsal eyes as large as the laterals, a little nearer together since the sides converge behind. Clypeus almost as wide as the radius of the median anterior eyes. Falces short, vertical, not ridged. Sternum scarcely wider than the intermediate coxæ. Labium twice as long as wide, rounded at the tip. Coxæ of the first separated by at least the width

* In 1885, in our work on the Genera of the Attidæ, we substituted the name *Epeus* for Simon's name *Evenus*, this latter being preoccupied. It seems very probable that *Epeus* and *Athamas* should form but one genus, but we have no specimen of *Epeus*, and are unable, from the description given by Simon, to decide the point. The generic and specific descriptions of *Epeus* are translated from Simon.

of the labium, of the same length as the others. Legs: 3, 1, 2–4, long, the three first pairs equal in thickness, the fourth more slender; patella and tibia of the first longer than the cephalothorax, tibia much longer than patella; patella and tibia of the fourth much longer than patella and tibia of the third, and more slender; metatarsus and tarsus of the fourth at least as long as patella and tibia; on the two first pairs two rows of very long inferior tibial and metatarsal spines; tibiæ and metatarsi of the two posterior pairs furnished with slender spines throughout their length. Tarsal claws long, regularly curved; the external one provided with a series of five broad, short, conical teeth; the internal one with ten teeth which are longer, more slender, equal, close together.

EPEUS TENER SIMON. 1876.

♀. Cephaloth.: length 3.6 mill., width 2.6 mill. Abd.: length 4.5 mill., width 1.5 mill. Legs: first 9 mill., second 8.4 mill., third 10 mill., fourth 8.4 mill.

White testaceous, with the circumference of the eyes black. Clypeus ornamented with thick, very white hairs. Cephalic square ornamented above with scaly pubescence of a brilliant, slightly gilded yellow, and on the sides with red pubesecence. Abdomen bright red above, with two fine lateral yellow lines. Legs and palpi glabrous.

Malamoy, Bassilan Island (Philippine Islands).

GROUP III. SIMONELLII.

GENUS SIMONELLA PECKHAM.

Body long, slender, nodose. Cephalothorax more than twice as long as wide, convex above, constricted near the middle; thoracic part twice as long as cephalic. Eyes very unequal in size, placed in four transverse rows of two each, those of the anterior row nearly touching; quadrangle formed by the second and fourth rows of eyes, equally wide in front and behind or wider behind than in front, and wider than long. Eyes of the third row very small, sometimes halfway between the second and fourth rows, sometimes nearer the second than the fourth.

Legs slender, differing but little in thickness; relative length 4, 3, 1, 2.

Abdomen long and slender, sometimes constricted in the middle.

SIMONELLA AMERICANA PECKHAM. 1885.

Plate XII, figure 4.

Simonella americana P., Proc. Nat. Hist. Soc. of Wisconsin, p. 24.

♂. Total length 8.5 mm. Width of of abdomen 1.1 mm.

Length of cephalothorax 3.5 mm; width 1.4 mm; height 1.2 mm.

Legs 3.8, 3.6, 4, 5.3.

Cephalothorax nearly as high as wide; cephalic and anterior thoracic parts higher and more convex than the remaining portion of the thoracic, from which they are separated by a well-marked constriction; that part of the thorax posterior to the constriction is highest in the middle, and slants off to form the narrow pedicle by which it is united to the abdomen. The cephalic and anterior thoracic parts are jet black and glabrous; the posterior thoracic part is pale yellow. Eyes of first row more than twice as large as those of the second; second row wider than the first; third row nearer the second than the fourth; eyes of fourth row about as large as those of second and further apart.

Clypeus less than one-half as high as anterior eyes, retreating; ridged above; color black. Palpus black, long and slender, having on outer side of tibia a stout apophysis. Falces robust, narrowing toward the tip, long, vertical, slightly diverging; fang as long as the palpus, slender, yellowish black in color. Maxillæ yelowish black, half as long as palpus, more than twice as long as labium; widest at their extremities. Labium as wide as long, truncated at tip.

Sternum yellowish, long, truncated in front, narrowing to a point behind.

Legs with weak tibial and metatarsal spines on the first pair; second, third and fourth pairs unarmed. Patella and tibia of the third, shorter than patella and tibia of the fourth; metatarsus and tarsus of the fourth, shorter than patella and tibia of the fourth. Patella, tibia and metatarsus of the first black on the inner side; otherwise all the legs are yellowish with a darker shading toward the distal ends of of those of the fourth pair. Abdomen made up of three parts, the middle part being a narrow neck which joins the anterior and posterior portions. The anterior is twice as long as the middle, and half as long as the posterior part.

Habitat: Guatemala.

This species was found running on the ground among leaf-cutting ants.

SIMONELLA MYRMECIÆFORMIS* TACZANOWSKI. 1874.

Plate XII, figure 8.

Janus myrmeciæformis Tacz., Les Aranéides de la Guyane française, p. 94.

Eyes in four rows; cephalothorax in two parts, abdomen with a marked constriction in the middle; general color ochre yellow, four black spots on the head, two pale rings on the abdomen. Length ♂ 7 mm.

♂. The cephalothorax is very slender and much elongated, with the head a little longer than wide, distinctly separated by a marked constriction across the back and throughout the height of sides; the thoracic part considerably longer than the head, a little narrower and composed of three distinct portions of which the anterior represents a short slightly contracted neck, which is followed by a convex knob, behind which is a rather long pedicle which is more slender than the neck; the cephalic plate is lightly arched and inclined forward; the lateral contours of the head are arched; behind it is terminated by a facet with a gentle slope. Eyes in four rows, in a quadrangle a little longer than wide;† those of the first row very large, in contact, and occupying the entire height and width of the face; those of the second pair behind on the lateral border of the back at a considerable distance from the preceding ones, and directed upward; eyes of the third pair halfway between those of the second and fourth; external border of the anterior eyes in a straight line and parallel with those of the other pairs. Falces short, thick and vertical. Abdomen longer and more slender than the cephalothorax, strongly constricted in the middle so as to form three distinct parts, of which the anterior is cylindrical, almost horizontal, the second very slender and strongly bent and the posterior elliptical, of the same breadth, but much longer than the anterior, that is to say the whole resembles an S faintly bent and enlarged at the two extremities. The spinnerets are short. The legs are slender and of moderate length, in the order 4, 3, 1, 2. Palpi short, thicker than the legs, with the tibæ short and stouter than the femora. The body is entirely bare, only a few hairs being found around the anterior eyes, on the tarsi of the palpi, and some which are almost imperceptible on the legs.

Coloration: The general color is a pale ochre yellow; two large black spots are found on each side of the head at the base of the eyes, the anterior one of which extends between those of the second and third

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* The descriptions of this species and of *lucasii* are translated from Dr. Taczanowski.

† This is true when the quadrangle is understood to include the first row of eyes; when we use the expression "quadrangle of the eyes" in relation to the Lyssomanæ (as in defining this genus) we refer to the quadrangle formed by the *second* and *fourth* rows of eyes.

pairs; two wide rings clearer than the general color are found around the abdomen, the first being in the middle of the anterior part, the second on the constriction. In the individual from Saint Laurent de Maroni the posterior part of the abdomen is grayish, much deeper than the rest of the body. The legs are of the color of the body but a little paler. The anterior eyes are amber yellow, the others blackish.

Two males from Cayenne and St. Laurent de Maroni; female unknown.

SIMONELLA LUCASII TACZANOWSKI. 1874.

Plate XII, figure 9.

Janus lucasii Tacz., Les Aranéides de la Guyane française, p. 96.

Eyes in four rows; cephalothorax in two parts, abdomen with a constriction near the base; color of cephalothorax reddish yellow; four black spots on the head; abdomen grayish. Length ♀ 4 mm.

♀. Cephalothorax slender and elongated, with the head square, distinctly separated from the thoracic part by a strong constriction, terminated behind by an inclined slope. The sides parallel and perpendicular; the thoracic part longer but not so wide as the head, is comopsed of a much contracted but short neck, followed by a globular knob, which is terminated behind by a short pedicle which is more slender than the anterior constriction. The eyes are in four rows, but are arranged a little differently from those of the preceding species; the ocular quadrangle is a little longer than wide;* the anterior eyes are large, in contact, occupying the entire front of the vertical inclination of the face; the second pair is placed on the back behind the eyes of the first pair, but they are a little further from each other than the distance between the external borders of the first ones, and are directed sideways; the posterior eyes are larger, but are separated by the same distance as those of the second row, the eyes of the third pair halfway between the second and fourth. The falces are short, thick and vertical. The abdomen is of the same length as the cephalothorax, thicker, commencing by a short pedicle which appears to constitute a prolongation of that of the thoracic part; behind this it suddenly grows larger up to the middle of its length and then grows smaller again so as to terminate in a point. The legs are slender and not very long, in the order 4, 3, 1, 2. All the body is glabrous, with some sparse hairs, which are rather long on the upper part of the head, and on the posterior part of the back of the abdomen.

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*The quadrangle is wider than long if the second row of eyes is taken as its anterior line. See note under preceding species.

Coloration: The color of the cephalothorax is reddish yellow, two black spots on each side of the head of which the anterior one includes the base of the eyes of the secoud and third pair. The abdomen is grayish yellow. The legs are pale yellow; the femora and the patellæ in the two posterior pairs are of a brownish gray, so as to form a wide clear ring at the origin of the leg. The anterior eyes yellow, the others black.

A single female from Uassa.

DESCRIPTION OF PLATES.

PLATE XI.

1. Lyssomanes antillanus, palpus of ♂.
2. " unicolor, palpus of ♂.
3. " viridis, palpus of ♂.
4. " bi-tæniatus, palpus of ♂.
5. " placidus, palpus of ♂.
6. " miniaceus, palpus of ♂.
7. " austerus, palpus of ♂.
8. " tenuis, palpus of ♂.
9. " jemineus, palpus of ♂.
10. " nigro-pictus, palpus of ♂.
11. " velox, palpus of ♂.
12. " longipes, palpus of ♂.
13. " robustus, palpus of ♂.

PLATE XII.

1. Lyssomanes amazonicus, palpus of ♂.
2. Asamonea gracilis, palpus of ♂.
3. Athamas whitmeei, palpus of ♂ (after Keyserling).
4. Simonella americana, palpus of ♂.
5. Asamonea tenuipes, palpus of ♂.
6. Lyssomanes viridis, epigynum; 6a, eyes; 6b, falces of ♂.
7. Lyssomanes robustus, eyes.
8. Simonella mymeciæformis, cephalothorax (after Taczanowski).
9. Simonella lucasii, cephalothorax (after Taczanowski).
10. Lyssomanes modestus, epigynum.
11. Athamas whitmeei, epigynum (after Keyserling).

12. Lyssomanes tristis, epigynum.
13. " blandus, epigynum.
14. " jemineus, epigynum.
15. " parallelus, epigynum.
16. " amazonicus, epigynum.
17. " austerus, epigynum.
18. Asamonea flava, epigynum.
19. " tenuipes, epigynum; 19a, eyes; 19b, falces.
20. Asamonea punctata, epigynum.
21. Lyssomanes unicolor, epigynum.
22. Asamonea ornatissima, epigynum.

O. M. CONOVER.

BY WM. F. ALLEN.

In the spring of 1884, the Academy experienced the loss of one of its most valued members, in the death of Obediah Milton Conover, which occurred in London, April 29 of that year. He was at the time on his way home from a two years' sojourn in Greece and Germany. His remains were brought to this city, and were committed to the earth in Forest Hill Cemetery, on the 28th of May.

Dr. Conover was of Dutch origin, being the seventh in the line of descent from Jacob Wolfertson van Kouwenhoven, who came to this country at its first settlement, in company with the Patroon van Renssellaer. On what occasion the name was changed to its present form is uncertain. His mother, Sarah Miller, was of a Kentucky family. He was born in Dayton, Ohio, October 8, 1825; prepared for college in that city, and graduated at Princeton in 1844, afterwards studying theology in the same institution (graduating in 1849), without, however, entering the profession of the ministry. In the interval of two years between his graduation and his theological course, he taught school near Lexington, Ky., and in Dayton. While at Dayton he also studied law in the office of Gen. Robert C. Schenck; and this was the profession he finally adopted, being admitted to the Dane county bar in 1859.

In 1849 he was married and came directly to Madison, where he resided the remainder of his life; his wife died in 1863. At first he was engaged in the publication of *The Northwestern Journal*, a literary and educational monthly, of which only a few numbers were published. In 1850 he was made professor of ancient languages in our University; an office which he held until 1858. It was the day of small things for the University, but no institution could be insignificant, or could fail to exert a strong and lasting influence, whose faculty consisted of three such men as Chancellor Lathrop, Professor Sterling and Dr. Conover. In 1859, as has already been said, he was admitted to the Dane County bar; two years later he became assistant reporter to the Supreme Court, and in 1864 was appointed reporter, which office he held until his death, a term of twenty years. During some years he held also the office of State Librarian. In 1879 he received from the University the degree of Doctor of Laws. In September, 1882, he was married to Mrs. Sarah Fairchild Dean, and they immediately went to Greece, where they spent the ensuing winter.

Mr. Conover was not a man of showy parts, and neither his disposition nor his taste led him to seek publicity. Besides this, in the later years of

his life the condition of his health did not permit him to undertake any but necessary routine labors. For these reasons he was seen but little except by his nearest friends, or in the performance of his public duties; and it was only those who were closely associated with him who were able to estimate him at his true worth. The community, however, did not fail to appreciate his high qualities. He was equally characterized by accuracy of information, soundness of judgment, and a high standard of conduct; and these qualities combined gave him an influence the strength and extent of which he was himself probably far from suspecting. It may be said that no man among us inspired more universal confidence, or was regarded with more universal esteem. Always courteous and unassuming, he was a man of strong convictions, and held to his opinions with great tenacity, although without intolerance.

In his public duties, as reporter to the Supreme Court, all his best intellectual qualities found room for exercise. His published reports, if I am rightly informed, rank among the best of their class. But while performing his professional duties faithfully and with high intelligence, he found his truest enjoyment in the study of literature — using this word in its highest significance. He was familiar with the best that has been said by the great creative minds of the world, and his fine taste and correct judgment were nowhere more marked than here. It was the chief happiness of his life that at its very close he was enabled to gratify this taste without stint, and in the most congenial companionship. The master spirits of Greek literature had always been his favorite writers; and the winter spent by him in Athens, where the American School of Classical Studies had just been established, brought him into direct and loving communion with the choicest memories of classical antiquity. Much as his friends in Madison regret that he was separated from them during the last two years of his life, they recognize that this experience was to him the greatest happiness that he could have wished. His relations to literature were, however, for the most part those of enjoyment and culture. He wrote very little himself, but that of a quality which one would wish to see more common. The members of the Madison Literary Club will remember with high appreciation the few papers which he read before them; and to most of us it was no doubt an unexpected, although by no means a surprising revelation, when he came to be known as being possessed of a poetic faculty, genuine, although rarely exercised.

As a member of our Academy there is little to be said of him. He had not the physical strength to do any work for it. I do not remember that he ever took an active part in its proceedings; but its members always felt it as a privilege and an honor to count him as one of themselves.

PROCEEDINGS OF THE ACADEMY SINCE DECEMBER, 1883.

REPORT OF THE SECRETARY.

FIFTEENTH REGULAR ANNUAL MEETING.

Held at Madison, Wisconsin.

ROOMS OF WISCONSIN ACADEMY OF
SCIENCES, ARTS AND LETTERS,
CAPITOL, MADISON, WISCONSIN.

FIRST SESSION.

MONDAY EVENING, December 29, 1884.

The reports of President, Secretary and Treasurer were presented.

Messrs. Lamb, Allen and Blackstone were appointed a committee on Treasurer's report.

Dr. Hoy, Profs. Daniells and Sprague were appointed a committee on nominations for membership.

SECOND SESSION.

December 30, 1884.

Academy met at 9 A. M.

The report of the Treasurer, showing a balance in the Treasury of $742.38, was reported back from the Auditing Committee, and its adoption recommended. The report was adopted.

The following members were elected:

Mr. F. E. Short, Madison; Mr. G. H. J. Douglass, Madison; Prof. F. B. Power, Madison; Mr. Carl Doerflinger, Milwaukee; Prof. A. J. Rogers, Milwaukee.

Voted: That a credit of $3.00 on his annual dues be allowed to Rev. S. D. Peet for his American Antiquarian for 1884.

Voted: That Prof. W. F. Allen be requested to prepare a memorial of Prof. O. M. Conover for the next volume of the Academy Transactions:

Dr. P. R. Hoy, of Racine, gave an interesting address on "How did the Indians make their stone implements?" The statements made by the doctor were somewhat startling to the gatherers of these ancient implements. Specimens of some of these very ancient implements were exhibited by the doctor, that had been made within the past six months, by a resident of our state, and not an Indian either.

Rev. S. D. Peet, of Clinton, addressed the Academy on recent investigations of the Indian mounds in this section of the state, particularly near the banks of Lakes Koshkonong and Mendota.

Mr. Peet also read a paper on the "Antiquity of Man in America," and the conclusion reached was that those who claimed the great antiquity of man in America had failed to prove their claims, and that the whole matter was still an open question.

The discussion of the question was continued by Prof. Birge, Dr. Hoy and Prof. Irving.

Prof. W. F. Allen read a paper on the "Changes in the Local Condition of the English Serfs during the Feudal Period."

AFTERNOON SESSION.

The first paper read was by Dr. P. R. Hoy, of Racine; on "Science and Society." The discussion of the subject was continued by Prof. J. S. Butler, Prof. E. A. Birge, Prof. Hoy, Prof. Peckham, Rev. S. D. Peet, and Prof. W. W. Daniells.

Prof. L. Heritage read an interesting paper "On the Date of the Dialogus de Oratoribus." The question was further discussed by Prof. W. F. Allen, Prof. E. S. Holden, Prof. Heritage and Prof. Butler.

Prof. C. A. Van Velzer gave an address on the "The Rapid Decomposition of Rotinal Fractions."

The question of the organization of affiliated societies came up for consideration, and was discussed by Prof. Birge, Prof. Peckham, Prof. Sprague, Prof. W. F. Allen, Prof. E. G. Smith, Dr. Hoy, Rev. S. D. Peet, Prof. Holden, A. O. Wright and Prof. Van Velzer.

Before acting upon the matter the meeting adjourned until 8 o'clock in the evening.

EVENING SESSION,

Academy called to order by Prof. T. C. Chamberlin, Vice-President.

The president, Prof. R. D. Irving, addressed the Academy on the subject of Geology in a most able and interesting manner.

The Academy then proceeded to the election of officers for the ensuing three years, which resulted as follows:

President — Prof. T. C. Chamberlin, Beloit.
Vice Presidents —
Department of Sciences — Prof. G. W. Peckham, Milwaukee.
Department of Arts — Prof. A. R. Sprague, Racine.
Department of Letters — Prof. W. F. Allen, Madison.
Secretary — Prof. E. A. Birge, Madisou.
Treasurer — S. D. Hastings, Madison.
Curator of the Cabinet — Prof. C. R. Van Hise, Madison.
Librarian — Prof. E. A. Birge, Madison.

The matter of affiliated societies was again taken up and settled by the adoption of the following: Any local, scientific or literary society may apply for affiliation with the Academy, submitting its constitution, etc., to the inspection and approval of the Academy. If affiliated, it may propose for membership in the Academy such of its members as it shall select. These persons will be considered as nominated for membership in the Academy, and, if elected, will be entitled to all privileges of regular members. The society shall pay to the Academy one-half of the regular annual dues of the Academy for each person so elected, and will be entitled to as many copies of future volumes of the trans-

actions of the Academy as it contains members of the Academy. In case of the discontinuance of a local society, these persons can continue as members of the Academy on payment of the regular dues.

A list of the officers, and the names of the members and a copy of the minutes of the meetings of affiliated societies shall be forwarded to the Academy, and the whole or such portion as the council shall think best shall be published in the report of the transactions of the Academy.

SIXTEENTH REGULAR ANNUAL MEETING

Held at Madison, Wisconsin.

FIRST SESSION.

ROOMS OF THE AGRICULTURAL SOCIETY,
MONDAY, December 28, 1885, 8 P. M.

President T. C. Chamberlin in the chair.

The report of the Treasurer was read as follows:

Balance at opening of year	$742 38
Receipts	92 00
	$834 38
Payments	48 30
Balance, December 29, 1885	$786 08

Referred to committee consisting of Prof. Butler, Prof. Peckham, and Prof. Salisbury.

Professors Allen, Van Hise and Higley were appointed a committee on new members.

Professors E. S. Holden and Wm. Trelease having removed from the state were made corresponding members.

SECOND SESSION.

TUESDAY, December 29th, 9 A. M.

Paper: "On Darwin," Prof. E. A. Birge.

Paper: "The Village Community and Serfdom in England," Prof. W. F. Allen.

THIRD SESSION.

TUESDAY, 2 P. M.

Paper: "Overproduction," Pres. A. L. Chapin.

Paper: "James Bridges," Prof. J. D. Butler.

The Treasurer's report was, on report of auditing committee, approved.

E. Simon, of Paris, France, was made an honorary member.

Annual members elected:

H. W. Hilyer, Madison; H. H. Powers, Madison; L. M. Hoskins, Madison; M. A. Miner, Green Lake; Prof. A. W. Burr, Beloit; C. E. Eschweiler, Milwaukee.

FOURTH SESSION.

TUESDAY, 8 P. M.

One hundred dollars was appropriated for cuts.

One hundred dollars was appropriated for library.

President's address:

Paper: "Drift Phenomena of Dakota, Montana, Idaho, and Washington Territories."

FIFTH SESSION.

WEDNESDAY, December 30, 9 A. M.

Prof. A. R. Sprague in chair.

Paper: "Principles of Hydraulics not yet incorporated in Water Wheels," D. P. Blackstone.

Paper: "Northern Pitcher Plant," W. K. Higley.

SIXTH SESSION.

WEDNESDAY, 2:30 P. M.

Paper: "Process of Determining Nitrogen," H. P. Armsby.

SEVENTEENTH REGULAR ANNUAL MEETING,

Held at Madison, Wisconsin.

ACADEMY ROOMS, CAPITOL BUILDING,
DECEMBER 28, 1886, 8 P. M.

Reports of President and Secretary were given verbally.

Treasurer's report:

Balance at commencement of year	$786 08
Receipts	60 00
Interest	40 00
	$886 08
Expenditures	132 94
	$753 14

Examined by auditing committee, found correct, and adopted on report of committee.

WEDNESDAY, 10:00 A. M.

"The Basal Conglemorate of the Huronian,"
Professor R. D. Irving, - - - Madison.

"Constitution of the Residuary Clays,"
Professor R. D. Salisbury, - - - Beloit.

"Glacial Phenomena about the Head of Lake Michigan,"
President T. C. Chamberlin, - - - Beloit.

2:30 P. M.

"Bowlder Trains of Dodge, Dane and Rock Counties,"
Professor I. M. Buell, - - - - Madison.

"Disinfection,"
Professor F. B. Power, - - - Madison.

"Science and Society,"
Dr. P. R. Hoy, - - - - Racine.

"The Genesis of the Town,"
Professor W. F. Allen, - - - Madison.

7:30 P. M.

"Limitations of Political Economy,"
President John Bascom, - - - Madison.

"The Methods of Science,"
Professor J. J. Blaisdell, - - - Beloit.

Dr. Chapin and Prof. Allen were appointed a committee on new members.

Business.

Elected to membership:

Prof. T. B. Pray, Whitewater; Prof. J. J. Blaisdell, Beloit; Dr. C. O. Whitman, Milwaukee; Mr. E. P. Allis, Jr., Milwaukee; Mr. Chas. A. Carr, Madison; Mr. C. H. Sylvester, Boscobel.

Resolved, That the President and Curator be directed to provide for the proper care of the type set of fossils in the possession of the Academy.

Resolved, That the thanks of the Society be tendered to the Governor of the State, for the room which the State has given the Academy, in the Capitol Building.

EIGHTEENTH REGULAR ANNUAL MEETING,

Held at Madison, Wisconsin.

SENATE CHAMBER,
DECEMBER 29, 1887, 8 P. M.

President Chamberlin in the chair.

The reports of the officers were made, and that of the Treasurer was referred to the usual auditing committee.

Professors Wright, Pray, and Birge were appointed a committee on nomination of officers.

President T. C. Chamberlin then gave an address on "The Origin of the Extra-Moraine Drift."

Prof. W. F. Allen read a memorial of the late Dr. O. M. Conover.

Officers for the term of three years were then elected as follows:

President—W. F. Allen, Madison.

Vice-Presidents—Department of Sciences, F. H. King, River Falls; Department of Arts, A. J. Rogers, Milwaukee; Department of Letters, J. J. Blaisdell, Beloit.

Librarian—E. A. Birge, Madison.

Treasurer—Hon. S. D. Hastings, Madison.

Curator—C. R. Van Hise, Madison.

The election of Secretary was postponed for one day.

FRIDAY, December 30, 9 A. M.

The following persons were elected to membership:

Prof. C. R. Barnes, Prof. S. J. Browne, Prof. J. W. Stearns, Prof. G. C. Comstock, Prof. W. A. Henry, Dr. J. M. Dodson, Dr. H. B. Favill, R. G. Thwaits, F. J. Turner, L. M. Hoskins, F. G. Short, F. W. A. Woll, all of Madison; G. H. Balg, Mayville; Pres. E. D. Eaton, Beloit; Prof. J. R. Emery, Ft. Atkinson; Emory McClintock, Milwaukee; C. E. McLenegan, Milwaukee; W. H. Metcalf, Milwaukee; Dr. N. Senn, Milwaukee; Dr. J. T. Reeve, Appleton; Prof. J. W. Stump, Whitewater.

On motion, the report of the Auditing Committee, recommending the acceptance of the Treasurer's report, was adopted.

Professor W. F. Allen read a paper:

The Economic Disturbance in Rome, A. D. 33.

Professor Lucius Heritage on the reading:

Aliquid Quam in Tacitus De Oratoribus.

Professor J. D. Butler:

The Imagery of Dante.

The retiring Secretary, E. A. Birge, was made a life member.

FRIDAY, 2:30 P. M.

Papers.

Professor J. E. Davies:

Interpretation of certain Symbolical Facts in Mathematical Physics.

Also:

A Possibly New View of the Nature of the Electric Current.

Professor E. A. Birge:

Certain Zoogloeas described by Prof. Wm. Trelease.

Prof. G. W. Peckham, of Milwaukee, was elected Secretary.

Voted: That the Academy express its interest in the studies of Prof. W. K. Higley, of Chicago on "The Distribution of plants in Wisconsin."

FRIDAY, 8 P. M.

Papers read:

"Terminal Moraines in North Germany,"

Prof. R. D. Salisbury.

"The Raised Beaches of Lake Michigan,"

Mr. Frank Leverett.

Voted: That the expenses for the ensuing year be regulated by the council.

Adjourned *sine die.*

E. A. BIRGE,
Secretary.

WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS.

LIFE MEMBERS.

Birge, Prof. E. A.
Case, Hon. J. I.
Dewey, Hon. Nelson
Delaplaine, Gen. Geo. P.
Davies. Prof. J. E.
Hill, James L.
Hoyt, Hon. John W.
Lawler, Hon. John
Mitchell, Hon. John L.
Paul, Hon. Geo. H.
Thorpe, Hon. J. G.

CORRESPONDING MEMBERS.

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Fallows, Bishop Samuel
Holland, Rev. F. May
Holden, Prof. E. S.
Knapp, Judge J. G.
Peet, Rev. S. D.
Steele, President G. M.
Sawyer, Prof. W. C.
Shipman, Col. S. V.
Trelease, Prof. Wm.

ACTIVE MEMBERS.

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Barnes, Prof. C. R.
Blaisdell, Prof. J. J.
Burr, Prof. A. W.
Beatz, Hon. Henry
Buell, Prof. Ira M.
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Butler, Prof. J. D.
Beach, Prof. W. H.
Blackstone, Prof. D. P.
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Chamberlin, Pres. T. C.
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Daniells, Prof. W. W.
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Greene, Thomas A., Esq.
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Heritage. Prof. Lucius.
Hoy, Dr. P. R.
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Higley, Prof. W. K.
Hillyer, Prof. H. W.
Hoskins, Prof. L. M.
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King, Prof. F. H.
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Lapham, Mary J.
Morgan, Prof. D. H.
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Meacham. Dr. J. G., Jr.
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Maxon, Rev. H. D.
Nader, Capt. John
Mills, Hon. Simeon
Norton, R. G., Esq.
Orton, Hon. H. S.
Olin, Mrs. D. A.
Perkins, Prof. H. B.
Peckham, Prof. G. W.
Parkinson, Prof. J. B.
Pray, Prof. T. B.
Power, Prof. F. B.
Rogers, A. J., Esq.
Smith, Prof. E. G.

ACTIVE MEMBERS—Continued.

Smeiding, Prof. Henry E.
Sprague, Prof. A. R.
Salisbury, Prof. R. D.
Sylvester, Prof. C. H.
Stump, Prof. J. W.
Somers, Rev. A. N.
Tatlock, Prof. John, Jr.
Viebahn, Prof. C. F.
Van Velzer, Prof. C. A.
Van Hise, Prof. C. R.
Whitford, Hon. W. C.
Wright, Prof. A. O.
Weyburn, Prof. L. A.
Wheeler, Prof. W. M.
Whitman, Prof. C. O.
Young, Rev. A. A.

TRANSACTIONS

OF THE

WISCONSIN ACADEMY

OF

SCIENCES, ARTS AND LETTERS.

VOL. VIII.—1888-1891.

PUBLISHED BY AUTHORITY OF LAW.

MADISON, WISCONSIN:
DEMOCRAT PRINTING COMPANY, STATE PRINTERS.
1892.

COUNCIL.

(Term expires December, 1898.)

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GEO. W. PECKHAM, Milwaukee.

Vice-Presidents,

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A. H. TOLMAN, Ripon.
FREDERICK B. POWER, Madison.

Secretary,

WM. H. HOBBS, Madison.

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SAMUEL D. HASTINGS, Madison.

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THE SECTIONAL FEATURE IN AMERICAN POLITICS.

By HUMPHREY J. DESMOND.

It is not always easy to determine the main threads of political history; but in the century of American Presidents, ending with the month of April, 1889, one intermittent and ever recurring question has been that of sectionalism. And the question waits among the perplexities of the new century.

There are grounds for regarding it as thus far *the controlling fact* in American politics. It was an overshadowing issue long before the slavery agitation was launched, and it continues a problem of to-day, long after slavery has ceased, and the irrepressible conflict has been fought out. All the larger events of the constitutional epoch carry a significance to the fact of sectionalism, gain an interest and importance from their relation to that fact, and may be grouped along its length as off-shoots from the main stem.

The theory which regards the constitution as a "compact between the states" may have been true in a formal way, and on that account plausible among the doctrinaires; the essential condition, however, was not a union of states, but a treaty of alliance between two great sections having opposite civilizations and diverse interests. And it is this condition, and not a theory, that confronts us in our survey of the first century in American politics.

The theory figured on both sides of Mason's and Dixon's line — the Hartford Convention being no less extreme a manifestation of states' rights than the episode of nullification. But the condition never fluctuated nor lost its consistency or purpose. It continued from the first to

> "Divert and crack, rend and deracinate
> The unity and married calm of states."

New issues were sought from time to time, but they were merely temporary aberrations. There was the trivial controversy, which for many days, went on in the convention of 1787, between the larger and the smaller states. Even then, the greater question was waiting. The absurd fear of the smaller states that a closer union would result in their absorption by the larger commonwealths being allayed, Madison admonished his colleagues that the states were divided into different interests, "not by their difference in size, but by other circumstances; the most material of which resulted partly from climate, but principally from the effect of their hav-

ing or not having slaves. It did not lay between the large and small states. It lay between north and south."

Having satisfied the smaller states with equality in the senate, the convention proceeded to its vital act of compromise, by establishing equilibrium between the sections — equalizing their strength in congress and in the electoral college.

No explanation has ever been offered as to how the particular fraction, "$\frac{3}{5}$", was selected in determining what weight the number of slaves should have in the apportionment of representation. The motion came from a New England member. Many years afterward, the question was put to Madison in a Virginian assemblage, but he preserved silence. It remains among the curious mysteries of that historic convention which have never been cleared up. A plausible explanation is furnished in a pamphlet entitled, "The Lost Principle," published at Richmond on the eve of the Civil war.[1] The anonymous writer argues that "$\frac{3}{5}$" was chosen in order to preserve the equilibrium of the sections; that the South would never have consented to it on any other plea. If the negro at the south were counted as a whole man and not as three-fifths of a man, the slave-holding states would possess a clear majority in the first electoral college.

The balance became apparent in the census of 1790. The population of the northern states was found to be 1,977,000; that of the southern states, 1,952,000. The admission of Vermont, Kentucky and Tennessee established a perfect balance in the senate — eight slave-holding states and eight free states, making up the union at the beginning of the century.

Federalism and Anti-Federalism proved a transitory issue — the great fact of sectionalism asserting itself with a dominant earnestness, after Hamilton had broken with Madison; and after the pregnant controversy of the Secretary of State with the Secretary of the Treasury, across the council boards of Washington's first cabinet. It had cropped out even in the selection of that cabinet; it came forth aroused at Hamilton's fiscal proposals; it manifested itself in southern objection to the admission of Vermont, and in northern objection to the admission of Kentucky. By the end of Washington's term, the lines were fully and sharply drawn; much to the distaste and displeasure of the father of his country, too. In his farewell address, he expresses serious concern that "ground should have been furnished for characterizing parties by geographical discriminations," regarding it as a serious disturbance to the union. Such discriminations appeared in a marked degree when the task of choosing his successor was reached. New England gave her solid vote to John Adams. The South cast six sevenths of her vote for Thomas Jefferson. Down to 1840, the same sectional proceeding was rehearsed in every presidential contest.

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[1] The Lost Principle, by Barbarrossa. Richmond, 1860. The author is supposed to be Robert Scott, of Virginia.

II.

It would be merely repeating familiar history to describe the frequent sectional clashes that ensued down to the eve of secession. Both north and south were thoroughly alive to the sectional bearing of every important question. Nobody doubts the statesmanship of the Louisiana purchase; yet that broad and praiseworthy stroke of patriotism was bitterly misliked at the time[1] and the hostility came wholly from New England, jealous of the chance for increased prestige which this new territory gave the south. The Hartford Convention of 1812, was the culmination of New England's anti-national feeling: open threats to "cut the connection" with the major part of the union and secret plottings to invite Canadian and British alliance are evidences of the rampant disunionism there prevalent. The South and the West never forgot the disloyalty of New England, during the war of 1812: and we see the force of reproach which that record had, in Haynes' debate with Webster, twenty years later. That famous debate, and the strained relation smoothed by the Missouri compromise in 1820, indicated how irrepressible a fact sectionalism had become.

Up to 1850, we have the phenomenon in our political history, which has been spoken of as "the twin birth of states." Every additional free state was followed by the admission of a slave state in order "to preserve the balance." The sectional leaders began looking anxiously to the future, and as the contest grew in intensity, the south bitterly chided itself for acquiescing in the ordinance of 1787, which forbade slavery in the northwest territory, and in the Missouri compromise of 1820, which shut out slavery north of the thirty-sixth parallel. The annexation of Texas and the Mexican war were distinctively southern measures, planned by the soured statesmanship of Calhoun, to redress the balance and give the south new room for more state making. The northern Democracy came into the party convention of 1844, with a candidate and a platform adverse to the Texas policy of the south; but the south had its way. And at the same time, with the deliberate connivance of Calhoun, the United States receded from its position in the Oregon dispute with England. The forty-ninth parallel was accepted as our north-most boundary instead of 54 40; territory sufficient to carve out three northern states was needlessly surrendered to Great Britain in order to propitiate southern sectionalism. At the end Calhoun was badly deceived in the results expected from the Mexican war. These results eventually strengthened the free states, and gave them their final preponderance in the United States senate. The admission of California in 1850, placed the north one state in the lead for the first time since the days of Washington. The southern leaders began to perceive that the

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[1] "Twenty Years of Congress," by James G. Blaine, ch. 1, p. 14.

equilibrium of the sections was to be an impossibility in the future, and the plan of secession was broached as the ultimate sequel[1]

Webster, in his "7th of March speech," alleges that up to 1859, three-fourths of the places of honor under the United States government were held by southerners. Alexander Stevens, in his famous appeal against secession in 1860, drew the attention of his countrymen to the fact that since the beginning of the government the South had eighteen out of the twenty-nine justices of the Supreme court; sixty years of southern presidents to twenty-four of northern presidents; twenty-three out of thirty-five speakers of the House of Representatives; and eighty-six out of one hundred and forty foreign ministers. The South, as represented in the Senate, was thoroughly alert and determined to reject any appointees unfavorable to southern interests, or tainted with free soil convictions. Mr. Stevens challenged his fellow southerners to answer whether they could receive better treatment under any other government than they had under the Union, and whether they could compensate themselves for the loss of an advantageous partnership in any greater degree of influence and patronage.

III.

The South went out of the Union in 1860 not to preserve slavery, but in the disappointment of sectional defeat. It was not the institution of slavery that was threatened, but its extension as an element in the increase of the southern system. Even upon the threshold of his administration, Abraham Lincoln wanted the south to understand that the national government did not propose to interfere with slavery where that condition was established; but he stood for the policy, that slavery was an evil which should be isolated and not extended. When Lincoln declared that the nation could not go on existing, half slave and half free, his meaning was against the strife of slave sectionalism and free soil sectionalism, competing for the new states, and maintaining an equilibrium of liberty and servitude. Secession was the southern alternative to sectional-equilibrium-destroyed. As soon as the south lost an equal share in the political partnership, she made up her mind to go out. Her proportional importance might be respected, and slavery might be let alone. But when fate had ordained that proportion to be less than an equal one, the traditional political self-esteem of the south rebelled.

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[1] Mr Calhoun, in his speech of March 4, 1850, argues that the union was endangered by reason of a widespread discontent among the people of the southern section due to a feeling that "they cannot remain as things now are consistently with *honor* and safety in the Union"; and the "great and primary cause of this belief is in the fact that the *equilibrium* between the two sections in the government as it stood when the constitution was ratified and the government put in action has been *destroyed*.

What had destroyed the sectional equilibrium and made all the strenuous effort, the political finesse and the brilliant strokes of southern statesmen nugatory and impotent? The answer is: emigration.[1] Next to the fact of sectionalism, I conceive the phenomenon of nineteenth century emigration to America to be the most notable circumstance in our later history. It was greater numerically, than the vast barbarian migration that overturned the Roman empire. To my mind, it has wrought in the nation other important results besides the transformation of the sectional question, but if none other, that alone would have been enough. The belated colonization of America by Ireland and Germany gave the north her numerical preponderance in the census; enlarged her relative strength in the House of Representatives; filled the places in the east of the army of young men going west and then followed, in renewed waves of immigration, the western pioneers. Know nothingism arose like the specter of the alarmed slave master — the ghost of selfish occupancy whether vested in human chattels or in the chattel of social, political and industrial machinery — but the hope of creating a sectarian instead of a sectional line of demarcation failed. This clever expedient of the southern Whigs was futile to withhold the inevitable end of the equilibrium. And when the task of crushing the rebellion was upon the nation, the foreign born soldier was also thrown into the scale against the South; thousands of naturalized citizens were drafted into a school of patriotism which made them irreproachably American, and thousands of the descendants of an earlier emigration, typified in generals like Sheridan and Rosecrans, were also important elements in the victory of the north. Had this emigration gone to the South it would undoubtedly have counted in a different solution of the problem. Historians would not be able to trace a direct connection between the potato rot in Ireland and the Emancipation Proclamation. The three or four million emigrants who destroyed the sectional equilibrium were tools in the hands of Providence. Yet there was nothing accidental in the fact that their weight was cast with the North and against the South. It could not have been otherwise.

John C. Calhoun, in his last great speech in the senate, delivered in the year of his death, 1850, sought to explain the waning strength of the South by deploring the fact that slavery was shut out of the territory north of the Ohio river and north of the 36th parallel. He also bewailed the influence of the existing revenue system which he conceived to result in attracting the emigrant population to the North and robbing the South of her capital. Under other conditions he thought that the South would have re-

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[1] The growth in the tide of immigration will appear from the following figures:

Immigrants,	1789 to 1820 (estimated)	250,000
"	1821 to 1830	143,439
"	1831 to 1840	599,125
"	1841 to 1850	1,713,251
"	1851 to 1860	2,598,214

Sixty per cent. of the immigration up to 1890 was Irish.

ceived her share of the emigration, and the census of 1850 would show a population in the slave states equal to that in the free states. Now the truth of the matter is that without the tariff, and with the fullest reign of squatter sovereignty, the result would not have been different. The North was destined to obtain the bulk of emigration in any event. The natural repulsion and antipathy between free labor and slave labor settled the question in advance. Slavery would have starved free labor out of the South, even had it sought entrance there. The peculiar civilization of the South gave the North all the advantages of development. Had southern leadership at the start been of the style of Jefferson Davis and Robert Toombs, rather than of the temperament and range of Madison and Jefferson, the lead which the South gained and held for sixty years could never have been. The natural growth of the country was against her equilibrium; but the traditions of a lofty statemanship kept her in the ascendant. It might have been foretold at the treaty establishing equilibrium of the sections in 1787 that unless emigration was to be shut out, as well as the importation of slaves, after 1807, the South was doomed to numerical inferiority.[1] Otherwise it was starting a nation with all the conditions of enlargement and progress, with healthy life currents and virile institutions in a race for the ascendancy with a nation already palsied by servitude and mortgaged in half its energies to an effete civilization. The ship which caught in its sails every breeze from over the Atlantic was bound, even against odds, to outstrip the slaver becalmed in a dead sea.

IV.

A table of the sectional electoral vote in the leading Presidential contests since 1796, will show that the war has had no effect on the animus of the sections. New England and the South are still at opposite poles. But a table of the apportionment of the electoral vote under the several censuses since 1790, will illustrate important changes. Classing Delaware as a southern rather than a middle state, our table indicates that the South cast nearly one half of the vote of the electoral college at the beginning. She casts thirty-eight per cent. of the electoral votes under the census of 1880. The New England section had twenty-eight per cent. of the electoral vote in 1790; to-day she has less than ten per cent. of it. The middle section consisting of New York, Pennsylvania and New Jersey has declined much less than New England, and rather less than the South; while the West which cast a little more than one-fifth of the electoral vote when Abraham Lincoln was a candidate, now casts a third of the whole vote, and bids fair to cast almost half the vote which shall elect a president in 1924.

---

[1] Draper's American Civil War, I 446, puts this opinion in the mouth of the slaveholder; "The mistake with us has been that it was not made felony to bring in an Irishman when it was made piracy to bring in an African."

ELECTORAL APPORTIONMENT BY SECTIONS FROM 1790 TO 1890, WITH PERCENTAGES.

Sections.	1790-1800		1800-1810		1810-1820		1820-30		1830-40		1840-50		1850-60		1860-70		1870-80		1880-90	
	Electors.	Per cent.	Electors.	Per cent.	Electors.	Per cent.	Electors.	Per cent.	Electors.	Per cent.	Electors.	Per cent.	Electors.	Per cent.	Electors.	Per cent.	Electors.	Per cent.	Electors.	Per cent.
New England	39	29	45	26	51	24	51	20	50	17	55	16	41	14	39	13	40	11	38	9½
Middle States	34	25	57	33½	62	30	72	29	81	29	69	25	69	24	66	21	73	20	75	19
Western States	...	...	...	...	7	3	24	10	33	12	40	14½	62	23	95	30	115	31	135	33½
Southern States	66	47	81	47½	96	43	114	41	125	42	114	42	130	39	114	36	138	38	153	38
Total Electoral Vote	139	....	176	...	217	..	261	.....	288		275		296	..	314	....	366	..	401	...

SECTIONAL DIVISIONS IN TEN LEADING POLITICAL CONTESTS, 1796-1884.

Sections.	1796.		1800.		1824.		1828.		1840.		1844.		1856.		1860.		1876.		1884.	
	Jefferson. (Dem.)	Adams. (Fed.)	Jefferson. (Dem.)	Adams. (Fed.)	Jackson and Crawford.	Adams and Clay.	Jackson. (Dem.)	Adams. (Whig.)	Van Buren. (Dem.)	Harrison. (Whig.)	Polk. (Dem.)	Clay. (Whig.)	Buchanan. (Dem.)	Fremont. (Rep.)	Breckenridge and Douglas.	Lincoln. (Rep.)	Tilden. (Dem.)	Hayes. (Rep.)	Cleveland. (Dem.)	Blaine. (Rep.)
New England	.....	39	...	39	...	51	1	50	7	43	15	28	...	41	...	41	6	34	6	32
Middle States	14	20	30	11	12	30	48	24	55	42	62	23	34	35	3	66	44	29	45	30
Western States	...	...	...	...	7	17	24	...	25	33	26	13	68	38	..	73	15	103	15	120
Southern States	54	12	53	12	91	23	105	9	48	78	57	47	112	...	81	.....	119	19	153	...
Total	68	71	73	65	110	121	178	83	60	234	170	107	174	111	84	180	184	185	219	182

In both tables Delaware is classed as a Southern State.

The admission of four new states to the Union will further tend to overthrow the old sectionalism. Dakota, with an area larger than any other political division except Texas, with a rapidly growing population, and with sufficient fertility to support three million people, has properly been divided into two states. Washington and Montana having passed the requirements respecting population, have come in as growing and influential states.

The effect of these new additions to the Union, so far as the historic sections are concerned, may be estimated as follows: In the electoral college—the southern system of states will have 156 votes; the northern system will have 270 votes.

In the Senate sixteen southern states will be represented by thirty-two seats; twenty-six states of the northern system will have fifty-two seats.

In the House of Representatives, the South will be entitled to some 120 congressmen; the North will be entitled to over 220 congressmen.

The most insurmountable political ascendancy is, of course, more probable in the United States Senate that elsewhere. Sectionalism throughout our entire political history has nowhere been better preserved. While the country has been broken up irrespective of Mason and Dixon's line in the House of Representatives, and while great states of the North have shifted their political allegiance with a reassuring spontaneity at Presidential elections, the Senate has always continued in a large sense a mirror of deep rooted geographical differences. With a brief and uncertain interval of doubt it has now been uninterrupted possession of the preponderant party of one section for nearly thirty years, and unless new and unforeseen events or issues arise, it bids fair to continue that political ascendancy for many years longer.

V.

The growth of the West has established a counter-balance to southern sectionalism, and the overthrow of slavery has tended to remove the essential difference between northern and southern civilization. Though the bitterness of the struggle for equilibrium has survived the war, there has been a growing recognition of the transformed condition of the problem. Bellicose politics have gone out, shirted in ridicule; ridicule which is the right medicine for all earnestness that outlives its purpose. And the imaginary danger from a solid South is apt to yield to some considerations:

1. It is perceived that the south is solid to-day rather for domestic than for national reasons: it is not a sectional caucus solidified for the purpose of gaining some contention against the other sections as it figured in antebellum days. It is rather a domestic problem which makes the South solid. The white man has grappled with the black bear: and he has no choice about letting go. The South is solid to save herself and not to domineer over the nation.

2. Sectionalism of a sort we must always have. We cannot escape it. Sectionalism which arrays the nation into two hostile camps and maintains an equilibrium of political power at the price of propagating slavery is deplorable; but that kind of sectionalism is fortunately destroyed; its causes blotted out; its chance of recurrence satisfactorily removed by the growth of the west, and the story of emigration. Sectionalism, which does not divide the nation into two geographical camps or into hostile civilization; but which may split it up into three or more congeries of states at issue on matters which do not go so deep as the long standing feud between Cavalier and Puritan is tolerable. And it is inevitable.

The sectionalism which makes the South solid to-day, or which may make its solidity a condition in the future, is to be looked upon as of this milder character. The west may furnish us, in the years to come, the most conspicuous phase of such sectionalism.

In fact, the issue of the late Presidential contest was said to aim at creating "a new sectionalism"—one that might cleave the country from north to south, and array the states into manufacturing and agricultural belts. A brief epoch of that kind of sectionalism might be wholesome in getting the nation away from its old partisan moorings, and casting overboard the effigies of a conflict that was well ended, if it had been ended quickly.

The question of Canadian annexation is a matter somewhat related to our sectional question. Following our system of government, an independent Canada would be a lesser United States speaking the same language, cherishing similar institutions and one with us in race and religion. Such a neighbor would be a powerful magnet of disintegration should the New England and Middle States, for instance, disagree with the South and West on any important issue, and be hopelessly out-voted in Congress. The commercial interests of these sections might draw them into an alliance with the Canadian Republic, ending in the setting up of a new confederacy. This, of course, is rather problematical, but it is often the unexpected that happens. Either we must annex Canada, or Canada will disintegrate us. And it may be a serious question whether it is not better to take her while she is young and tractable, rather than wait until antipathies in political feelings are too far generated to make union easy and agreeable.

It remains to be said that if, for the sake of a perfect Union, we would wish to have as little sectional feud in the future, as possible, we must be observant of the strict letter of the constitution and learn to admire it as warmly for the restraints it imposes on Federal power as for the functions it grants.[1]

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[1] Prof. Bryce (Am. Commonwealths, II., 693) believes that "the United States are no more likely to dissolve than if they were a unified republic like France or a unified monarchy like Italy." He notes "the growing strength of the centripetal and unifying orces"—in which there is no little danger.

A federal government attempting to do a great many things in a great many directions is sure to arouse warring interests and clashing influences. And in a country which reaches from the Atlantic to the Pacific and touches the tropics, and stretches out to the land of the midnight sun, all such interests and influences are more or less geographical and sectional.

ARTIFICIAL KEYS

TO THE

GENERA AND SPECIES OF MOSSES

RECOGNIZED IN LESQUEREUX AND JAMES'S MANUAL OF THE MOSSES OF NORTH AMERICA;

By CHARLES R. BARNES,

Professor of Botany in the University of Wisconsin, Madison, Wis.

INTRODUCTORY.

In the summer of 1886 I published a key to the genera of mosses recognized in the Manual of Lesquereux and James. From the demand which has exhausted a large edition of that key, I have felt that the object of its publication was reasonably attained, that it really was helpful to students of mosses. Although much misgiving was felt as to its accuracy a considerable use of it has revealed but one serious omission, and neither time nor its users have indicated to the author how it could be materially improved. It is therefore reprinted here with the few alterations which have seemed desirable.

But since there are no keys to the species even of the largest genera in the Manual, the novice, deserted after reaching the genus, is left almost as much bewildered as if he had not been led so far. I have therefore been induced to prepare keys to the species of all the genera.

The only plea for such work is its anticipated usefulness. I hope that it will stimulate some to undertake the study and collection of mosses who have heretofore been deterred by their helplessness in the determination of them without more expensive aids than the amateur usually possesses. An earnest student equipped with patience, some skill in dissection, a compound microscope and the Manual, ought to be able with the additional assistance of these keys to determine the names of most of the mosses which he can collect. Those which remain uncertain he can refer to those who possess the illustrations and exsiccati which are often indispensable for identification. I shall be disappointed if these keys do not encourage more to enter upon the study of this exceedingly interesting group of plants, which, with the Hepaticæ, are more neglected than any of which we now have accessible descriptions.

In constructing these keys, I have thought it wise to make few changes in the nomenclature or in the rank of species. Of many in the Manual neither the present names nor the autonomy can be maintained. The changes I have made are, with one exception (Dicranum fuscescens), confined to the two genera which have been revised since the appearance of the Manual in 1884, viz., *Sphagnum*, by M. Jules Cardot, of Stenay, France, and *Fissidens*, by the author. M. Cardot is now engaged in a revision of *Fontinalis* and *Dichelyma*, and I regret that his results have not yet been published, that they might be included in the present keys.

I have included in the keys all the new species known to me which have been published since the issue of the Manual and before 1890, when the relation of these could be ascertained from the descriptions and figures.

(It is worth nothing that a considerable number of new species are about to be published in the *Bulletin of the Torrey Botanical Club* and in the *Botanical Gazette.*) Two genera, *Eucladium* and *Merceya*,[1] have been indicated as new to North America. The former has been included in the key to genera. The relationship of the latter is so problematical that I have been compelled to omit it.

The number in bold-face type following the name of a genus in the key to genera refers to the page of this publication where the key to its species may be found. The other number, in ordinary type, is that of the page in the Manual where it is described. When there is only the latter the genus contains but one species. The number following the species (in the keys to species) is the same as it bears in the Manual.

It will be found in a number of cases that the keys contradict characters assigned in the Manual. I have not knowingly permitted such contradiction without having good reasons therefor, so that they must be considered as corrections, and not accidental. There may be mistakes among them; it is highly probable that there are some elsewhere. I should be glad to receive notice of errors or omissions from any who detect them.

My thanks are due to Mrs. Elizabeth G. Britton, for kind assistance in several points.

CHARLES R. BARNES.

UNIVERSITY OF WISCONSIN, *February* 8, 1890.

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[1] *Merceya latifolia* Kindberg: *Bull. Torr. Bot. Club* xvi (1889) 94.

ANALYTIC KEY

TO THE

GENERA OF MOSSES.

ORDER I.— **Sphagnaceæ.**

Capsule dehiscing by a deciduous operculum, peristome none, leaves composed of large hyaline cells, with intervening rows of small chlorophyllose ones. Genus single . . . . . **Sphagnum**, 12. **24.**

ORDER II.— **Andreæaceæ.**

Capsule dehiscing by four (rarely six) longitudinal slits. Genus single . . . . . **Andreæa**, 25. **26.**

ORDER III.— **Archidiaceæ.**

Capsule bursting irregularly, spores few and very large. Genus single . . . . . **Archidium**, 49. **28.**

ORDER IV.— **Bryaceæ.**

Capsule bursting irregularly (spores numerous) or generally dehiscing by a deciduous operculum, in the latter case usually furnished with a peristome. Leaves not sphagnoid.

Genera numerous as follows:

I. CLEISTOCARPI.— *Capsule without a deciduous operculum.*

A. *Green protonema persistent.*

Leaves ecostate.

Capsule colorless . . . . . **Micromitrium**, 37. **26.**

Capsule colored . . . . . **Ephemerum**, 37. **26.**

Leaves costate . . . . . **Ephemerum**, 37. **26.**

B. *Green protonema not persistent.*

Margins of leaves flat or incurved.
Leaves lance-obovate to broad-ovate, not abruptly pointed . . . . . **Physcomitrella**, 39.
Leaves linear- lanceolate to subulate or abruptly pointed.
Calyptra mitrate . . . . . **Bruchia**, 45. **27.**
Calyptra cucullate . . . . . **Pleuridium**, 43. **27.**
[**Astomum** may be sought here.]

Margins of leaves more or less revolute.
Capsule spherical . . . . . **Sphærangium**, 40. **27.**
Capsule short-pointed.
Calyptra mitrate . . . . . **Microbryum**, 45.
Calyptra cucullate . . . . . **Phascum**, 41. **27.**

II. STEGOCARPI.—*Capsule with a deciduous operculum.*

A. ACROCARPI.—*Flowers and fruit terminating the stem, either the main shoot or a branch.*

1. *Mouth of the capsule naked.*

* *Leaf-cells isodiametric, at least above the middle of the leaf, often obscure.*

Lid imperfectly formed, persistent . . . . . **Astomum**, 51. **29.**
Lid perfect, deciduous.
Capsule immersed.
Leaves lamellose . . . . . **Pharomitrium**, 100.
Leaves not lamellose, ciliate . . . . . **Hedwigia**, 152.
Leaves with a hyaline hair-point . . . . **Grimmia**, 134. **43.**
Capsule exserted, ribbed when dry.
Calyptra cucullate.
Pedicel very short, strongly twisted to the left when dry . . . . . **Amphoridium**, 158. **46.**
Pedicel long, twisted to the right when dry . **Braunia**, 153.
Calyptra campanulate mitrate, plicate, usually hairy . . . . . **Macromitrium**, 178. **50.**
Calyptra long clavate-campanulate, not plicate nor hairy . . . . . **Encalypta**, 180. **50.**
Capsule exserted, not ribbed when dry.
Lid conic, beaked.
Pedicel short . . . . . **Calymperes**, 184. **50.**
Pedicel long . . . . . **Gymnostomum**, 52. **29.**
Lid conic, beakless, or conic-subulate . . . **Pottia**, 100. **37.**

Lid convex or flattish, beaked.
  Plants large (2 cm. +), leaves distichous . . **Eustichia**, 94.
  Plants large, leaves pluriseriate, papillose.
    Leaves linear-lanceolate, margins plane . **Anœctangium**, 54.
    Leaves ovate-lanceolate, margins reflexed, hyaline at base . . . . . **Barbula**, 115. **39.**
    Leaves lingulate-lanceolate, margins revolute, three-fourths hyaline . . . . . **Desmatodon**, 110. **38.**
  Plants small, leaves broader, hair-pointed or cuspidate or serrate, not papillose . . . . . **Pottia**, 100. **37.**
  Plants small or minute, leaves lance-subulate . **Anodus**, 96.
Lid long-clavate . . . . . **Encalypta**, 180. **50.**

* * *Leaf-cells plainly elongated, distinct.*

Lid small, convex or short-conic, capsule microstome.
  Leaves vertically inserted . . . . . **Schistostega**, 188.
  Leaves subulate, dentate . . . . . **Bartramia**, 203. **53.**
  Leaves broad, entire, calyptra enclosing capsule . . . . . **Pyramidula**, 196.
Lid large (rarely small), capsule macrostome.
  Capsule splitting at the middle . . . **Aphanorhegma**, 196.
  Capsule dehiscing regularly above the middle, not covered by calyptra . . . . . **Physcomitrium**, 196. **52.**

2. *Mouth of the capsule furnished with a peristome.*

* *Peristome single.*

+ *Teeth articulate.*

++ *Teeth eight.*

Leaves thick, coriaceous . . . . . **Octoblepharum**, 91.

[**Orthotrichum** and **Ptychomitrium** (§ *Notacisia*) may be sought here.]

++++ *Teeth sixteen, calyptra mitrate.*

= *Calyptra plicate.*

Teeth cribrose, purple . . . . . **Coscinodon**, 154. **46.**
Teeth filiform, trifid . . . . . **Ptychomitrium**, 156. **46.**
Teeth approximate or connate in pairs.
  Lanceolate to subulate, papillose . . . **Ptychomitrium**, 156. **46.**
  Triangular-lanceolate, articles quadrate.
    Basal leaf-cells linear, chlorophyllose . . . **Ulota**, 160. **46.**
    Basal leaf-cells hexagono-rectangular, hyaline **Orthotrichum**, 164. **47.**
Teeth short, pale, fragile . . . . . **Macromitrium**, 178. **50.**

= = *Calyptra not plicate.*

Aquatic, floating.
  Leaves distichous . . . . . **Conomitrium**, 89. **34.**
  Leaves pluriseriate . . . . . **Cinclidotus**, 134.
Terrestrial.
  Very small, gregarious.
    Teeth broad, erose-truncate, hyaline . . **Brachyodus**, 98.
    Teeth linear-lanceolate, deeply bifid . **Campylostelium**, 99.
  Larger, above 1 cm. in height.
    Leaf-cells small, quadrate or punctate, obscure.
      Beak long-clavate . . . . . **Encalypta**, 180. **50.**
      Beak long or short, not clavate.
        Teeth lanceolate, flat, subentire or cribrose or 2—3-fid to the middle . **Grimmia**, 134. **43.**
        Teeth linear-lanceolate, 2—3-fid to below the middle, or cleft to the base into filiform segments . . . **Rhacomitrium**, 147. **45.**
    Leaf-cells large, very distinct, pedicel with a prominent apophysis.
      Apophysis smaller than the capsule.
        Leaves entire, obtuse . . . . . **Dissodon**, 189. **51.**
        Leaves serrate, acute or acuminate . **Tayloria**, 190. **51.**
      Apophysis exceeding the capsule . . **Splachnum**, 193. **51.**

++ ++ ++ *Teeth sixteen, calyptra cucullate.*

= *Leaves distichous.*

Leaves subulate . . . . . **Distichium**, 93. **36.**
Leaves broader, with a prominent vertical wing . **Fissidens**, 81. **34.**

= = *Leaves pluriseriate.*

* *Capsule unsymmetric, cernuous-inclined or arcuate.*

Teeth filiform-bifid from a membranous base . **Desmatodon**, 110. **38.**
Teeth irregularly lacerate or bifid to the middle or below.
  Leaf cells not enlarged at the basal angles, roundish or quadrate above.
    Lid long-beaked, leaves serrulate, peristome equaling half the capsule . . . . . **Dichodontium**, 61. **30.**
    Lid long-beaked, leaves crenulate or denticulate, peristome shorter . . . . . **Cynodontium**, 59. **30.**
    Lid short-beaked . . . . . **Oreoweisia**, 58.
  Leaf-cells not enlarged at the basal angles, oblong above, rectangular at base . . . **Dicranella**, 61. **30.**

Leaf-cells enlarged-quadrate at the basal angles, linear at base . . . . . **Dicranum**, 67. **31.**
Leaf-cells of two kinds, in two or three layers **Leucobryum**, 90. **36.**
Teeth bifid to near the base.
Lid conic, leaves subulate . . . . . **Trichodon**, 92. **36.**
Lid conic, leaves lanceolate . . . . . **Ceratodon**, 92. **36.**
Lid aristate, neck very long . . . . . **Trematodon**, 62. **30.**
Teeth not cleft, short, irregular . . . . **Catoscopium**, 211.
Teeth not cleft, cohering by their tips . . **Conostomum**, 207.
Teeth not cleft, perforate.
Neck long, exceeding the capsule . . . . **Trematodon**, 62. **30.**
Neck inconspicuous, plants small . . . . **Discelium**, 188.
Neck inconspicuous, plants large . . . . **Oreoweisia**, 58.
Teeth not cleft nor perforate.
Lid with a short thick oblique beak . . **Oreoweisia**, 58.
Lid with a short slender oblique beak . **Cynodontium**, 59. **30.**
[**Mielichhoferia** and **Funaria** may be sought here.]

Capsule symmetric, pendulous on a flexuous pedicel.

Teeth bifid to the middle . . . . . **Campylopus**, 77. **33.**
Teeth bifid to the base, free . . . . . **Dicranodontium**, 77.
Teeth bifid to the common membranous base.
Connivent and slightly twisted . . . . **Desmatodon**, 110. **38.**
Erect, not twisted . . . . . **Trichostomum**, 108. **38.**
Teeth entire, short, plants minute . . . . . **Seligeria**, 96. **36.**

Capsule symmetric, erect.

Teeth bifid to the common membranous base.
Lid short, conic or beaked . . . . . **Desmatodon**, 110. **38.**
Lid elongated, conic. . . . . **Trichostomum**, 108. **38.**
[**Barbula** may be sought here.]
Teeth deeply bifid or cleft to the base, free.
Leaf-cells small, not enlarged at the angles, oblong above . . . . . **Dicranella**, 64. **30.**
Leaf-cells small, not enlarged at the angles, roundish or quadrate above . . . . . **Cynodontium**, 59. **30.**
Leaf-cells small, enlarged-quadrate at the angles . **Dicranum**, 67. **31.**
Leaf-cells large, distinct . . . . . **Angstrœmia**, 63.
Teeth cribrose, perforate or slightly cleft.
Leaf-cells enlarged-quadrate at the angles.
Capsule broad-pyriform . . . . . **Blindia**, 98.
Capsule oval to sub-cylindric . . . . **Dicranoweisia**, 57. **29.**

Leaf-cells not enlarged at the angles.
  Teeth large, mostly cribrose.
    Pedicel little exceeding the often hair-pointed leaves . . . . . **Grimmia.** 134. **43.**
    Pedicel long, leaves hair-pointed . . **Desmatodon.** 110. **38.**
    Pedicel long, leaves not hair-pointed.
      Leaves serrate just above sheathing base . **Eucladium.**[1]
      Leaves entire or crenulate above . . **Didymodon.** 104. **37.**
  Teeth small, often truncate or rudimentary.
    Leaf margins involute above . . . . . **Weisia.** 55. **29.**
    Leaf-margins revolute or plane.
      Leaves densely papillose in the upper part . **Didymodon.** 104. **37.**
      Leaves not papillose . . . . . **Pottia.** 100. **37.**
Teeth entire.
  Capsule with a long, thick apophysis . . **Tetraplodon.** 191. **51.**
  Capsule oval to subcylindric.
    Not ribbed when dry.
      Teeth short, leaves entire, narrow . . . **Weisia.** 55. **29.**
      Teeth short, leaves serrate, broad . . **Syrrhopodon.** 185. **50.**
      Teeth linear-filiform, connate at base . **Didymodon.** 104. **37.**
      Teeth narrowly lanceolate, free . . **Dicranoweisia.** 57. **29.**
    Ribbed when dry . . . . . **Rhabdoweisia.** 58. **29.**
  Capsule short-pyriform, turbinate when dry.
    Teeth blunt . . . . . **Seligeria.** 96. **36.**
    Teeth acute . . . . . **Blindia.** 98.
  Capsule pyriform, not turbinate when dry.
    Plants gregarious or subcespitose . . . **Entosthodon.** 199. **52.**
    Plants in deep, compact tufts . . . **Mielichhoferia.** 214.
  Capsule ovate-globose, lid obliquely long-beaked **Drummondia.** 160.
  Capsule globose, lid beakless, small . . . **Bartramia.** 203. **53.**

++++++++ *Teeth thirty-two.*

Teeth cancellate . . . . . **Barbula.** 115. **39.**
Teeth filiform or linear, almost terete, arising from a long or short basilar membrane.
  Short, slightly, if at all, twisted.
    Leaves subulate or lance-subulate from a broader base . . . . . **Leptotrichum.** 105. **37.**
    Leaves broader, lid elongated-conic . . **Trichostomum.** 108. **38.**
      [**Barbula** *rigidula* will be sought here.]
    Leaves broader, lid short-conic or short-beaked **Desmatodon.** 110. **38.**
  Long, twisted to the left . . . . . **Barbula.** 115. **39.**

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[1] *E. verticillatum.* Br. and Sch.: Renauld and Cardot: *Bot. Gaz.*, xiv. (1889), 99.

Teeth flat, not from a distinct basilar membrane.
Cells of capsule linear-oblong . . . **Dicranodontium, 77.**
Cells of capsule irregularly polygonal . . **Didymodon, 104. 37.**

+ + Teeth not articulate.

++ Teeth four, solid.

Capsule linear-oblong, stems long, conspicuous . . **Tetraphis, 186. 51.**
Capsule ovate, stems very short . . . . **Tetrodontium, 187.**

++++ Teeth thirty-two or sixty-four.

Calyptra cucullate, capsule symmetric or nearly so.
Leaves undulate-crisped when dry, lamellæ few (2—8), straight . . . . . **Atrichum, 255. 60.**
Leaves sub-tubulose at apex, lamellæ undulate or numerous . . . . . **Oligotrichum, 258. 61.**
Calyptra cucullate, capsule unsymmetric, arcuate incurved . . . . . **Psilopilum, 259.**
Calyptra mitrate, densely hairy.
Capsule not angular, teeth 32 . . . . . **Pogonatum, 260. 61.**
Capsule 4—6 angled, teeth 64 . . . . . **Polytrichum, 263. 61.**

** * Peristome double.*

+ Capsule symmetric, erect.

Teeth almost none, imperfect or rudimentary . **Macromitrium, 178. 50.**
Teeth perfect, linear, revolute, capsule smooth . **Schlotheimia, 179.**
Teeth linear or filiform, dark red or purple, capsule ribbed and twisted . . . . . **Encalypta, 180. 50.**
Teeth broadly or narrowly triangular-lanceolate, pale, capsule ribbed, not twisted.
Leaf-cells at base linear, chlorophyllose . . . **Ulota, 160. 46.**
Leaf cells at base hexagono-rectangular, hyaline **Orthotrichum, 161. 47.**
Teeth linear, contracted at articulations, capsule smooth, cylindric . . . . . **Leptotheca, 251.**

+ + Capsule unsymmetric, inclined or oblique or pendulous.

-- Inner peristome a plaited cone.

Pedicel thick, red, densely verrucose . . . . **Buxbaumia, 267.**
Pedicel very short, almost none . . . . . **Diphyscium, 266.**

++++ *Inner peristome a membrane, carinate or cut into sixteen segments; these sometimes separated by cilia.*

= *Cilia very short, rudimentary or none.*

Membrane entire, 16-carinate. . . . . **Cinclidium**, 249. **60.**
Membrane latticed or cleft to the base into filiform, appendiculate segments.
Pedicel none or very short, leaves ecostate . **Fontinalis**, 268. **62.**
Pedicel distinct, sometimes long, leaves costate . **Dichelyma**, 272. **63.**
Membrane not cleft to the base.
Segments entire or interruptedly cleft along the middle line.
Shorter than the teeth or rudimentary . . **Funaria**, 200. **52.**
Equaling the teeth in length.
Leaves squarrose-recurved from the middle . **Paludella**, 213.
Leaves not squarrose.
Pedicel long.
Leaf-cells narrowly rhombic-hexagonal, tending to linear, leaves narrow . . . . . **Webera**, 215. **53.**
Leaf-cells and leaf broader . . . . . **Bryum**, 223. **55.**
Pedicel short, neck long . . . . . **Zieria**, 240. **58.**
Far exceeding the teeth in length.
Pedicel long, leaf-cells large, pellucid . **Amblyodon**, 211.
Pedicel long, leaf-cells small, rectangular, chlorophyllose . . . . . **Meesia**, 212. **53.**
Pedicel short, neck long . . . . . **Zieria**, 240. **58.**
Segments bifid, divisions divaricate.
Leaves lanceolate to subulate, large . . . **Bartramia**, 203. **53.**
Leaves lanceolate or broader, smaller . . **Philonotis**, 208. **53.**
Segments filiform, united by fours at their tips . **Timmia**, 254. **60.**

= = *Cilia present.*

Appendiculate.
Leaves lance-subulate, cells linear . . . **Leptobryum**, 215.
Leaves broader, cells rhombic-hexagonal . . . **Bryum**, 223. **55.**
Inappendiculate.
Capsule not ribbed when dry.
Leaves lanceolate, glossy, cells narrowly rhombic-hexagonal, inclining to linear . . . . . **Webera**, 215. **53.**
Leaves ample, soft, oblong, ovate to obovate or broader, cells round-hexagonal . . . . . **Mnium**, 241. **58.**
Leaves narrowly lanceolate, rigid . . **Rhizogonium**, 250.
Capsule ribbed when dry.
Oblong or elongated pyriform . . . **Aulacomnium**, 252. **60.**
Sub-globose . . . . . **Philonotis**, 208. **53**

B. PLEUROCARPI. *Flowers and fruit lateral, in the axils of leaves.*
[**Fontinalis** and **Dichelyma** may be sought here.]

1. *Peristome single (rarely none), teeth eight or sixteen.*
[Species belonging to genera under "**B** * " *infra* may be sought here.]

Leaves distichous, with broad vertical wing . . Fissidens, 81. 34.
Leaves pluriseriate.
Entire.
Ecostate, abruptly long-acuminate, cells quadrate except in costal region, distinct . . Habrodon, 296.
Ecostate, cells linear or rhombic, obscure . . Leucodon, 287. 65.
Costate, short acuminate . . . Clasmatodon, 297.
Costate, obtuse, teeth 8, red . . . . . Cryphæa, 275. 63.
Serrate, capsule emergent . . . . . Leptodon, 278. 64.
Serrate to ciliate-dentate, capsule long-pedicelled . Fabronia, 294. 65.

2. *Peristome double, the inner often imperfect.*

* *Segments none or short, or obscured by adhering to teeth.*

+ *Leaves papillose.*

Entire, ovate to ovate-lanceolate.
Teeth ciliate-papillose . . . . . Leskea, 301. 66.
Teeth not papillose . . . . . Anomodon, 304. 66.
Entire or cristate serrate, obovate or spatulate Pterigynandrum, 288.
Spinulose-dentate to fimbriate (rarely entire) deltoid or round-ovate . . . . . Thelia, 298. 66.
Serrate, broadly ovate . . . . . Pterogonium, 289. 65.

+ + *Leaves not papillose.*

Capsule straight.
Segments bifid or adherent to the teeth.
Plants small (1–2 cm.), capsules about 2 mm. Pylaisæa, 308. 67.
Plants large (4–6 cm.), capsules about 4 mm. Cylindrothecium, 310. 67.
Segments not bifid nor adherent.
Leaves ecostate or obscurely bicostate . . Neckera, 281. 64.
Leaves costate . . . . . Antitrichia, 290. 65.
Capsule curved or arcuate . . . . . Homalothecium, 309. 67.

* * *Segments not distinctly keeled, narrow.*

+ *Leaves costate.*

Cells roundish to oval-rhombic.
Papillose [except in *Leskea pulvinata*].
Stem and branch-leaves similar . . . Leskea, 301. 66.
Stem-leaves much smaller than branch-leaves Anomodon, 304. 66.

Not papillose.
Annulus large, compound . . . . . **Cryphæa**, 275. **63.**
Annulus none, leaf-cells minute, obscure . **Neckera**, 281. **64.**
Annulus none, leaf-cells large, distinct **Anacamptodon**, 296.
Cells linear or vermicular.
Annulus none . . . . . **Neckera**, 281. **64.**
Annulus present . . . . . **Antitrichia**, 290. **65.**
[**Cylindrothecium**, with leaves obscurely costate, may be sought here.]

+ + *Leaves ecostate.*

Annulus none . . . . . **Neckera**, 281. **64.**
Annulus present.
Leaf-cells quadrate at basal angles . . **Cylindrothecium**, 310. **67.**
Leaf-cells not quadrate at basal angles . . **Orthothecium**, 315. **68.**

* * * *Segments distinctly keeled, often broad.*

+ *Capsule symmetric, erect.*

[Species of **Hypnum** with erect or sub-erect capsules will be sought here.]

Leaves papillose.
Plants large, branches erect, dendroid . . . . . **Alsia**, 279. **64.**
Plants long, pendent from trees, branches filiform **Meteorium**, 286. **65.**
Plants small, branches erect, julaceous . . **Myurella**, 300. **66.**
Leaves not papillose.
Leaves costate or ecostate, complanate, pseudo-distichous . . . . . **Homalia**, 285. **65.**
Leaves ecostate, annulus large (none in *Cyl. Drummondii*).
Cells quadrate at basal angles.
Teeth hyaline margined . . . . . **Platygyrium**, 307.
Teeth not hyaline margined . . **Cylindrothecium**, 310. **67.**
Cells not quadrate at basal angles . . **Orthothecium**, 315. **68.**
Leaves ecostate, annulus small, narrow . . . **Pylaisæa**, 308. **67.**
Leaves costate, plants dendroid . . . . . **Climacium**, 313. **68.**

+ + *Capsule unsymmetric, often arcuate.*

Leaf-cells large, calyptra mitrate.
Leaves mucronate or acute or acuminate . . **Hookeria**, 292. **65.**
Leaves obtuse . . . . . **Pterigophyllum**, 293.
Leaf-cells small, calyptra cucullate . . . . . **Hypnum**, 316. **68.**
[**Climacium** *Ruthenicum* will be sought here.]

ANALYTIC KEYS

TO THE

SPECIES OF MOSSES.

SPHAGNUM,[1] p. 12.

I. *Branches dimorphous, some divergent, some pendent: hyaline cells with fibrils.*

A. *Chlorophyllose cells near one face of leaf, triangular, triangular-elliptical or trapezoidal in transverse section.*

1. *Chlorophyllose cells on the ventral face of leaf; hyaline cells most convex on the dorsal face.*

a. *Branch leaves minutely fringed all around* . **S. Portoricense, 22.**

b. *Branch leaves not fringed.*

Walls of hyaline cells adjoining chlorophyllose cells furnished with a fringe of rudimentary fibrils . . **S. Austini, 21.**

Walls of hyaline cells adjoining chlorophyllose cells thickly papillose . . . . . **S. papillosum, 20.**

Walls smooth.

Cortical cells of stem fibrillose.

Chlorophyllose cells narrowly triangular or triangular elliptical . . . . . **S. cymbifolium, 19.**

Chlorophyllose cells very large, equilateral-triangular . **S. affine**[2].

Cortical cells porose, not fibrillose.

Stem leaves broadest at base . . . . . **S. acutifolium, 1.**

S. Wulfianum may be sought here

Stem leaves broadest in the middle . . . . . **S. molle, 13.**

Stem leaves broadest at apex . . . . . **S. fimbriatum, 4.**

Stem leaves of almost equal breadth throughout **S. Girgensohnii,**[3] **3.**

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[1] See Cardot: Revision des Sphaignes de l'Amérique du Nord, in Bull. Soc. roy. de bot. de Belgique, XXVI.

[2] Renauld & Cardot: Rev. Bryol. 1885, p. 41. See also Cardot: Sphaignes d'Europe in Bull. Soc. roy. de bot. de Belgique, XXV, p. 51, pl. 2, fig. 9 and 10 and pl. 3, fig. 5.

[3] S. strictum Lindb.

2. *Chlorophyllose cells on dorsal face of leaf; hyaline cells most convex on ventral face.*

a. *Cortex of stem distinct.*

Stem leaves very broad above and strongly fimbriate . **S. Lindbergii, 7.**
Stem leaves broadest below.
Branch leaves with narrow border . . . . . **S. tenellum, 18.**
Branch leaves with broad border . . . . . **S. cuspidatum, 5.**
Branch leaves not bordered . . . . . **S. Garberi, 14.**

b. *Cortex of two layers of small cells, indistinct, or wanting* . . . . . **S. intermedium, 6.**

B. *Chlorophyllose cells exposed on both faces or included, elliptic in transverse section.*

1. *Free on both faces.*

Cortex consisting of one layer of cells.
Branch leaves ovate-acuminate . . . . . **S. subsecundum, 15.**
Branch leaves round ovate . . . . . **S. cyclophyllum, 23.**
Cortex of more than one layer of cells.
Stem leaves large, rounded and fimbriate at apex, with narrow border below.
Branch leaves large, strongly squarrose . . **S. squarrosum, 8.**
Branch leaves smaller, slightly squarrose at tips . . **S. teres, 9.**
Stem leaves small, with broad border below . . **S. laricinum, 16.**

[**S. Wulflanum** may be sought here.]

2. *Included.*

Branches in fascicles of 7—12 . . . . . **S. Wulflanum, 10.**
Branches in fascicles of 3—5.
Cortex of 2 or 3 layers, with few small pores or none . **S. rigidum, 11.**
Cortex of 4 or 5 layers, pores numerous . . **S. medium, Limpr.**[1].

II. *Branches uniform, solitary or in pairs: hyaline cells fibrillose: cortical cells usually in one layer, without pores.*

Stem and branch leaves alike, broadly obtuse, entire or erose at apex . . . . . **S. Pylæsii, 26.**
Stem leaves oblong or obovate, branch leaves narrow, linear oblong . . . . . **S. Fitzgeraldi, 25.**

[1] Cardot: l. c., p. 5.

III. ***Branches uniform, all arcuate-divergent; hyaline cells without fibrils, those of the branch leaves with one or two central rows of pores.***

Hyaline cells of branch leaves with 5—10 pores in one row, **S. macrophyllum, 27.**

Hyaline cells of branch leaves with 40—60 pores in two rows . . . . . **S. Floridanum.**[1]

Of the species enumerated the following are reduced by M. Cardot:

SS. medium, papillosum, Austini and affine are sub-species of S. cymbifolium; S. laricinum of S. subsecundum; S. squarrosum of S. teres; S. Girgensohnii of S. acutifolium. and S. cuspidatum of S. intermedium.

S. rubellum Wils. becomes a variety of S. acutifolium; S. Muelleri Schimp. is a synonym of S. molle; S. Mendocinum S. & L. of S. cuspidatum; S. sedoides Brid. of S. Pylæsii.

S. cyclophyllum is believed to be an immature state of S. subsecundum, but is retained in the Key.

ANDREÆA, p. 25.

Costa 0.

Leaves incurved, minute, rotund-obtuse, deeply bi-ventricose . . . . . **A. parvifolia.**[2]

Leaves spreading or secund, acuminate, not ventricose **A. petrophila, 1.**

Costate.

Costa vanishing below apex . . . . . **A. rupestris, 2.**

Costa excurrent . . . . . **A. crassinervium, 3.**

MICROMITRIUM, p. 37.

Spores 63 μ diameter, leaves serrate . . . **M. megalosporum, 1.**

Spores 25 μ diameter, nearly smooth, leaves serrate above **M. Austini, 2.**

Spores a little smaller, papillose, leaves nearly entire . **M. synoicum, 3.**

EPHEMERUM, p. 37.

Leaves not costate . . . . . **E. serratum, 1.**

Leaves costate.

Costa ending below or at apex . . . . . **E. cohærens, 6.**

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[1] Cardot: l. c., p. 22.

[2] Müller: *Flora* 1887. 219.

Costa excurrent.
  Seta short, capsule acutely beaked. . . **E. stenophyllum, 7.**
  Seta 0, capsule blunt pointed.
    Leaves gradually long-acuminate, slightly and irregularly serrate at apex . . . . . **E. crassinervium, 2.**
    Leaves with a long hyaline spinulose arista . **E. spinulosum, 3.**
    Leaves papillose both sides . . . . . **E. papillosum, 4.**
    Leaves long-spinulose on both sides . . . **E. hystrix, 5.**

SPHÆRANGIUM, p. 40.

Leaves papillose on both faces . . . . . **S. Schimperianum, 4.**
Leaves smooth or papillose on back.
  Margins reflexed, plants triquetrous . . . **S. triquetrum, 3.**
  Margins almost plane, plants round or tetragonal.
    Lower leaves ecostate . . . . . **S. rufescens, 2.**
    Lower leaves costate . . . . . **S. muticum, 1.**

PHASCUM, p. 41.

Capsule sub-globose, apiculate.
  Leaf margins plane or incurved, denticulate . **P. Carniolicum, 1.**
  Leaf margins reflexed, quite entire . . . **P. cuspidatum, 2.**
Capsule ovate- or oblong-lanceolate . . . . - **P. bryoides, 3.**

PLEURIDIUM, p. 43.

Inflorescence paroicous.
  Costa reaching the obscurely serrate apex . . **P. subulatum, 1.**
  Costa excurrent into a smooth awl-shaped point . **P. Ravenelii, 2.**
Inflorescence autoicous.
  Upper leaves long subulate.
    Entire except at apex . . . . . **P. alternifolium, 3.**
    Serrulate from middle upward . . . . . **P. Bolanderi, 5.**
  Upper leaves abruptly short pointed . . . . . **P. Sullivantii, 4.**

BRUCHIA, p. 45.[1]

I. *Collum 0.*

Seta very short . . . . . **B. palustris, 1.**
Seta exceeding capsule . . . . . **B. Beyrichiana, 5.**

[**B. brevicollis** may be sought here.]

[1] This key must be quite imperfect, since the figures are so few, descriptions so imperfect and specimens so inaccessible that it is impossible to ascertain the characters in many instances.

II. *Collum present.*

A. *Equalling sporangium.*

Spores papillose . . . . . **B. Bolanderi, 4.**
Spores pitted . . . . . **B. brevifolia, 12.**

B. *Shorter than sporangium.*

1. *Calyptra papillose.*

Leaves denticulate at apex . . . . . **B. Ravenelii, 13.**
Leaves denticulate all around . . . . . **B. Hampeana, 14.**

2. *Calyptra smooth.*

a. *Leaves papillose* . . . . **B. Donnellii, 9.**

b. *Leaves smooth (subpapillose in* B. Sullivantii.)

i. *Costa not filling the narrowed point.*

Synoicous . . . . . **B. flexuosa, 2.**
Monoicous . . . . . **B. Sullivantii, 3.**

ii. *Costa broad above, filling point.*

Capsule immersed . . . . . **B. brevipes, 11.**
Capsule exserted.
  Leaves appressed . . . . . **B. Hallii, 8.**
  Leaves spreading.
    Seta straight.
      Collum more than ½ spore case . . . . . **B. Texana, 10.**
      Collum less than ½ spore case . . . . . **B. brevicollis, 6.**
    Seta geniculate at middle . . . . . **B. curviseta, 7.**

ARCHIDIUM, p. 49.

Autoicous.
  Costa reaching to point of leaf . . . . . **A. Ohioense, 1.**
  Costa often long excurrent . . . . . **A. Hallii, 5.**
Paroicous.
  Leaves serrulate . . . . . **A. tenerrimum, 2.**
  Leaves quite entire.
    Cells oval or rhombic . . . . . **A. Ravenelii, 3.**
    Cells quadrangular or quadrate . . . . . **A. longifolium, 4.**

ASTOMUM, p. 51.

Capsules often clustered (2–3), oblong-oval . . **A. Ludovicianum, 2.**
Capsules solitary.
  Orange, subglobose, leaves crispate when dry . **A. Sullivantii, 3.**
  Orange, oval, leaves not crispate . . . **A. nitidulum, var. 4.**
  Brown, shining, ovoid, leaves not crispate . . **A. nitidulum, 4.**
  Brown, globose, leaves crispate . . . . **A. crispum, 1.**

GYMNOSTOMUM, p. 52.

Lid long remaining attached to columella, capsule thick-walled, with 6–8 rows of transversely elongated cells at the mouth . . . . . **G. curvirostre, 3.**
Lid falling early, capsule thin-walled, with 3–4 rows of transversely elongated cells at mouth.
  Plants 1–2 mm. high, lid conic . . . . . **G. tenue, 4.**
  Plants 5–10 mm. high, lid subulate, costa 24—35 μ wide at base with 2 guides[1] . . . . . **G. calcareum, 1.**
  Plants 1–7 cm. high, costa 70 μ wide at base, with 4–6 guides[1] . . . . . **G. rupestre, 2.**

WEISIA, p. 55.

Inflorescence autoicous.
  Teeth more or less perfect or none, capsule wrinkled lengthwise when dry . . . . . **W. viridula, 1.**
Inflorescence dioicous.
  Teeth large, lacunose and bifid, capsule 8-sulcate . **W. longiseta, 2.**
  Teeth truncate, capsule not sulcate . . . . **W. Wolfii, 3.**

DICRANOWEISIA, p. 57.

Leaf cells at base thick-walled, linear (1:6–10) . . **D. crispula, 1.**
Leaf cells at base thin-walled, rectangular (1:2–3) . . **D. cirrhata, 2.**

RHABDOWEISIA, p. 58.

Leaves minutely denticulate or entire; teeth filiform, smooth, fugacious . . . . . **R. fugax, 1.**
Leaves coarsely dentate; teeth linear, obliquely crossed-striate . . . . . **R. denticulata, 2.**

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[1] See explanation under Dicranum, p. 31.

CYNODONTIUM, p. 59.

Annulus very narrow and persistent or 0.
  Leaf cells conical- to spinous-mamillose.
    Teeth not papillose, seta straight . . . . . **C. Schisti, 1.**
    Teeth papillose, seta often arcuate when moist . **C. gracilescens, 2.**
  Leaf cells not mamillose, papillose over partitions . . **C. virens, 4.**
Annulus distinct, revoluble . . . . . **C. polycarpum, 3.**

DICHODONTIUM, p. 61.

Costa vanishing below apex, seta yellow. . . . . **D. pellucidum, 1.**
Costa percurrent, seta red . . . . . **D. Canadense, 2.**

TREMATODON, p. 62.

Collum equalling or somewhat exceeding the oval-oblong sporangium . . . . . **T. ambiguum, 1.**
Collum greatly exceeding the cylindric sporangium . **T. longicollis, 2.**

DICRANELLA, p. 64.

I. *Cells of the exothecium rectangular-quadrate; seta red; costa usually broad and indistinct below.*

A. *Leaves not sheathing, erect-spreading.*

Costa percurrent or excurrent.
  Annulus 0, peristome papillose.
    Capsule cernuous, curved . . . . . **D. varia, 6.**
    Capsule erect, symmetric . . . . . **D. rufescens, 7.**
  Annulus present, peristome not papillose . . . **D. parvula.**[1]
Costa ceasing within the apex, annulus large, simple . **D. debilis, 8.**

B. *Leaves, from a sheathing base, squarrose.*

Broad, obtuse . . . . . **D. squarrosa, 4.**
Abruptly subulate.
  Capsule striate, substrumose, leaf apex entire . **D. Grevilleana, 2.**
  Capsule not striate nor strumose, leaf apex serrulate . **D. Schreberi, 3.**

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[1] Kindberg: *Bull. Torr. Bot. Club* xvi (1889) 91.

II. *Cells of the exothecium prosenchymatous; seta often yellow; costa narrow and well defined below.*

A. *Seta red.*

Leaves, from a sheathing base, squarrose . . . . . **D. crispa, 1.**
Leaves not sheathing nor squarrose.
  Mostly erect, capsule cernuous . . . . . **D. subulata, 9.**
  Secund, capsule erect . . . . . **D. curvata, 11.**

B. *Seta yellowish.*

Capsule symmetric, erect . . . . . **D. Fitzgeraldi.**[1]
Capsule cernuous.
  Strumose . . . . . **D. cerviculata, 5.**
  Not strumose . . . . . **D. heteromalla, 10.**

DICRANUM, p. 67.

In this genus the structure of the costa is of diagnostic value. It is either composed of similar cells (*homogeneous*), or composed of large parenchyma cells and small sclerenchyma cells (*stereïdes*). The large parenchyma cells ("Deuter" of Lorentz[2]: here translated *guides*) form a row (seldom double) in the middle of the costa, touching each other tangentially. They are comparatively large, but little thickened and either empty or starch-bearing.[3]

I. *Monoicous, stems radiculose only at base; costa long excurrent, homogeneous.*

Capsule erect, not strumose.
  Striate and furrowed when dry . . . . **D. hyperboreum Müll.**[4]
  Neither striate nor furrowed when dry . . . . **D. fulvellum, 1.**
Capsule cernuous, strumose.
  Leaf cells not papillose, capsule oblong-cylindric . **D. Starkei, 2.**
  Leaf cells with papillæ over the partitions, capsules short ovate.
    Leaves falcate-secund . . . . . **D. falcatum, 3.**
    Leaves spreading . . . . . **D. Blyttii, 4.**

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[1] Renauld & Cardot: *Bot. Gaz.*, xiii (1888) 197. pl. XIII.
[2] Pringsh. Jahrb. f. wiss. Bot., vi. 374.
[3] Cf. Limpricht: *Die Laubmoose*, p. 23.
[4] Barnes: MSS.: var. papillosum, Renauld & Cardot: *Bot. Gaz.* xiv. (1889). 91.

II. ***Dioicous, stems sub-radiculose above, costa flat, equalling or broader than the 2—4-stratose lamina whose superficial cells are without chlorophyll, capsule erect, regular.***

Costa not furrowed at back, smooth . . . . . **D. albicans, 11.**
Costa furrowed and toothed at back . . . **D. longifolium, 10.**

III. ***Dioicous, stems radiculose (often densely), costa with median guides.***

A. *Capsule cernuous, more or less arcuate.*

1. *Leaf cells pitted.*

a. *Costa not reaching the apex, leaves transversely undulate.*

Leaf cells above elongated, smooth.
Costa serrate on back, not lamellose.
Capsules solitary (rarely 2), annulus 0 . . . . **D. palustre, 19.**
Capsules clustered, annulus large, simple . **D. Drummondii, 22.**
Costa with serrate lamellæ.
Capsules clustered, perichætial leaves differentiated **D. undulatum, 23.**
Capsules solitary (?), perichætial leaves like others **D. dipteroneuron.**[1]
Leaf cells above isodiametric, irregular.
Smooth at back . . . . . **D. Schraderi, 20.**
Papillose at back . . . . . **D. spurium, 21.**

b. *Costa percurrent or excurrent, leaves not undulate.*

(**D. palustre** may be sought here.)

Guides in two rows . . . . . **D. majus, 18.**
Guides in one row.
Perichætial leaves abruptly subulate . . . . **D. scoparium, 17.**
Perichætial leaves gradually subulate . . . . . **D. Howellii.**[2]

2. *Leaf cells not pitted or faintly so.*

a. *Capsules cernuous, curved.*

i. *Leaves quite entire, subulate.*

Points very brittle and mostly broken . . . . **D. fragilifolium, 16.**
Points not broken . . . . . **D. elongatum, 12.**

ii. *Leaves entire, upper obtuse* . **D. Groenlandicum, Brid.**[3]

Lower cells rectangular (1:2-3) . . . . . **D. Miquelonense.**[4]

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[1] Müller: *Flora*, 1887, 221.

[2] Renauld & Cardot: *Bot. Gaz.* xiv (1889) 93, pl. XII.

[3] Syn. D. tenuinerve, Zett. - Renauld & Cardot: *Fl. Méq.* 12 (1888); *Bot. Gaz.* xiv. (1889) 93.

[4] Renauld & Cardot: *Fl. Méq.* 12 (1888); *Bot. Gaz.* xiv. (1889) 93, pl. XII.

III. *Leaves serrulate.*

Upper cells very irregular.
  Weakly papillose over partitions, capsule not striped, **D. congestum**, Brid.[1] 13.
  Not papillose, capsule striped.
    Inner perichætial leaves obliquely truncate to a short serrate subula . . . . . **D. Muhlenbeckii**, 14.
    Inner perichætial leaves narrowed to thong-shaped point . . . . . **D. rhabdocarpum**, 15.
    Inner perichætial leaves rounded with a short subula, **D. sabuletorum.**[2]
Upper cells regular, quadratic . . . . . **D. fuscescens**,[3] 13.

b. *Capsule erect, symmetric.*

Costa without stereïdes . . . . . **D. strictum**, 5.
Costa with two stereïde bands.
  Lamina above of two layers.
    Margin and costa serrulate . . . . . **D. fulvum**, 9.
    Entire, apex usually broken . . . . . **D. viride**, 7.
  Lamina throughout of one layer.
    Upper cells rectangular and mamillose . . **D. montanum**, 6.
    Upper cells less regular, not mamillose . . . **D. flagellare**, 8.

D. leioneuron and *D. stenodictyon* of Kindberg, *Ottawa Nat.* ii (1889) 155 and *Bull. Torr. Bot. Club* xvi (1889) 92, are species of uncertain relations. I have not seen authentic specimens, and the descriptions are too meager to enable me to form any judgment.

CAMPYLOPUS, p. 77.[4]

I. *Costa smooth at back.*

A. *Auricles none.*

[C. gracilicaulis may belong here.]

Upper leaves with hyaline points . . . . . **C. Henrici.**[5]
Upper leaves without hyaline points . . . . . **C. Leanus**, 4.

[1] *D. fuscescens* of Manual.
[2] Renauld & Cardot: *Bot. Gaz.* xiv (1889) 91, pl. XII.
[3] This is var. *longirostre* and var. *angustifolium* of Manual.
[4] The genus is greatly in need of revision, with a view to discovering differential structural characters of the leaves. The few figures and meager descriptions render the key uncertain in many points.
[5] Renauld & Cardot: *Bot. Gaz.* xiii (1888) 197, pl. XIV.

B. *Auricles present.*

No lamina except small colored auricles . . . . . **C. Hallii, 5.**
Lamina distinct.
Perichætial leaves concolorous.
Auricles brown.
Deeply concave . . . . . **C. flexuosus, 1.**
Plane, decurrent . . . . . **C. Tallulensis, 2.**
Auricles whitish, large.
Leaves serrulate at apex . . . . . **C. subleucogaster, 7.**
Leaves spinulose serrate at apex . . . . . **C. Donnellii, 8.**
Auricles dirty red . . . . . **C. augustiretis, 11.**
Perichætial leaves with hyaline points (may include 8 and 11 above) . . . . . **C. gracilicaulis, 10.**

II. *Costa scabrous or lamellose at back.*

Leaves with pellucid hair points . . . . . **C. introflexus, 3.**
Leaves not hair pointed.
Alar cells round, lamina 0 . . . . . **C. frigidus, 6.**
No auricles . . . . . **C. Virginicus, 9.**

FISSIDENS, p. 81 (*incl. Conomitrium, p.* 89.[1])

I (EUFISSIDENS.) *Plants terrestrial or submersed but not floating; leaves soft, of one layer of cells.*

A. *Fruit terminal.*

1. *Monoicous, male flowers axillary.*

Leaf-cells small, densely chlorophyllose, in distinct rows **F. limbatus, 5.**
Leaf-cells larger, not densely chlorophyllose, nor in distinct rows . . . . . **F. bryoides, 2.**

2. *Dioicous or monoicous with the male flowers terminal on a rooting branch at the base of the female stem.*

a. *Leaf-cells* 1½–2 *times as long as wide, large, distinct.*

Plants less than 1 mm. high, leaves two or three pairs **F. Closteri, 1.**
Plants 2–4 mm. high, wholly hyaline, leaves 3–5 pairs **F. hyalinus, 9.**

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[1] See Barnes: *Bot. Gaz.*, xii (1887) 1.

b. *Leaf-cells almost or quite isodiametric, often obscure.*

Leaves with a narrow border, at least on vaginant lamina.
Marginal leaf-cells not papillose . . . . . **F. incurvus**, 3.
Marginal leaf-cells papillose.
Costa percurrent . . . . . **F. Ravenelii**, 13.
Costa ceasing below apex . . . . . **F. Garberi**, 15.
Leaves without a border.
Acute, cells densely chlorophyllose, obscurely papillose **F. Donnellii**, 14.
Obtuse, cells pellucid, operculum conic . . **F. obtusifolius**, 17.
Apiculate, operculum with acicular beak . . **F. osmundoides**, 18.
Leaves with a thick reddish border. Plants submersed, rigid . . . . . **F. rufulus**, 8.[1]

B *Fruit lateral.*

1. *Leaves without a border.*

Obtuse, entire, plants 2–5 cm. high, fruit sub-terminal **F. polypodioides**, 23.
Rounded at apex, irregularly serrate, 1–2 cm. high, fruit sub-basal . . . . . **F. sub-basilaris**, 22.
Mucronate, regularly serrulate, fruit basal or sub-basal **F. taxifolius**, 20.

2. *Leaves bordered by several rows of paler, often incrassate, cells.*

Capsule cernuous, leaf-cells minute . . . . . **F. Floridanus**, 7.
Capsule erect or inclined, flowers dioicous, leaf-cells obscure . . . . . **F. decipiens**, 19.
Capsule erect or inclined, flowers monoicous, leaf-cells distinct . . . . . **F. adiantoides**, 21.

II. (PACHYFISSIDENS.) *Leaves rigid, composed of more than one layer of cells, opaque.*

Plants growing in water or very wet places . . **F. grandifrons**, 24.

III. (OCTODICERAS.)[2] *Plants aquatic, filiform, floating.*

Plants large, much branched, pedicel shorter than the capsule . . . . . **F. Julianus**, C. 1.
Plants small, little branched, pedicel longer than the capsule . . . . . **F. Hallianus**, C. 2.

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[1] *F. ventricosus*, Lesq.
[2] *Conomitrium* of Manual.

In the Revision of N. A. species of Fissidens,[1] FF. inconstans, exiguus and minutulus were reduced to F. incurvus, the two latter forming varieties. FF. bryoides var. cæspitans, crassipes, Hallii and Texanus are relegated to the list of doubtful species.

Two species have recently been named by Renauld and Cardot[2] as occurring in the U. S., *FF. Bambergeri* Schimp. and *viridulus* Wahl. The first of these I regard as a form of F. incurvus; the second is possibly a sub-species of the same. It may be known by its thin-walled capsule, with the peristome inserted below the mouth. Neither are worthy of a distinct place in the key.

LEUCOBRYUM, p. 90.

Capsule apparently lateral (by innovations), leaves erect-spreading, oblong lanceolate . . . . . **L. vulgare,[3] 1.**
Capsule exactly terminal, leaves squarrose, very short and very broad . . . . . **L. sediforme, 2.**

CERATODON, p. 92.

Stems 2–3 (sterile often 10) cm. long, teeth articulate for ⅔ length . . . . . **C. purpureus, 1.**
Stems 5 mm. long, teeth articulate to middle . . . **C. minor, 2.**

TRICHODON, p. 92.

Cells of leaf base linear, above rectangular . . . **T. cylindricus, 1.**
Cells of leaf base rectangular (1:2–4), above quadrate . **T. flexifolius.[4]**

DISTICHIUM, p. 93.

Capsule erect, spores 17–20 μ . . . . . **D. capillaceum, 1.**
Capsule cernuous, spores 30–44 μ . . . . **D. inclinatum, 2.**

SELIGERIA, p. 96.

Seta straight when moist.
Leaves sharp pointed, cells above rectangular, spores 10–14 μ . . . . . **S. pusilla, 1.**
Leaves blunt-pointed, cells above quadratic, spores 14–18 μ . . . . . **S. calcarea, 2.**

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[1] See Barnes: *Bot. Gaz.* xii (1887) 1.

[2] *Bot. Gaz.* xiv (1889), 99.

[3] *L. minus* cannot be separated. L. vulgare varies from 3 to 20 cm. in height and good fruit can be found in the same tuft from December to August.

[4] Renauld & Cardot: *Bot. Gaz*, xiv, (1889) 94, pl. XIII.

Leaves mostly blunt-pointed, cells rectangular, spores 24–32 μ . . . . . **S. tristicha, 4.**
Seta arcuate when moist . . . . . **S. recurvata, 3.**

POTTIA, p. 100.

I. *Peristome 0 or rudimentary.*

Costa with 2–4 lamellæ above . . . . . **P. cavifolia, 1.**
Costa not lamellate.
  Leaf-margins more or less revolute.
    Lid conic obtuse, spores echinate . . . . **P. minutula, 2.**
    Lid rostellate, spores papillose.
      Calyptra smooth . . . . . **P. truncata, 3.**
      Calyptra scabrous . . . . . **P. Wilsoni, 4.**
  Leaf-margins plane or involute.
    Lid abruptly rostrate, leaves sharply serrate above . **P. Heimii, 5.**
    Lid conic, leaves distantly denticulate above . . **P. riparia, 6.**
    Lid conic-subulate, leaves slightly crenulate above . **P. Barbula, 7.**

II. *Peristome distinct.*

Leaves oblong-lanceolate, margins revolute . . . **P. Starkeana, 8.**
Leaves rounded or round-spatutate, margins plane . **P. latifolia, 9.**

DIDYMODON, p. 104.

Leaf cells throughout quadratic . . . . . **D. luridus, 2.**
Leaf cells below rectangular.
  Leaf base reddish, margins above revolute . . . **D. rubellus, 1.**
  Leaf base hyaline, margins plane . . . . **D. cylindricus, 3.**

LEPTOTRICHUM, p. 105.

Dioicous.
  Leaves slightly twisted.
    Stem leaves spreading, perichætial leaves hardly sheathing . . . . . **L. tortile, 1.**
    Stem leaves imbricate, perichætial leaves long sheathing . . . . . **L. vaginans, 2.**
  Leaves not twisted.
    Plants short (1–2 cm.), not radiculose . . . **L. homomallum, 3.**
    Plants long (to 10 cm.) densely radiculose . . **L. flexicaule, 4.**

Monoicous.
Plants short (5 mm.)
Teeth cylindric, nodose-articulate, leaves spreading . **L. pallidum, 5.**
Teeth flattened, linear, trabeculate, perforate, leaves secund . . . . . **L. Schimperi, 6.**
Plants longer (2–3 cm.), glaucous . . . . **L. glaucescens, 7.**

TRICHOSTOMUM, p. 108.

I. *Lamina composed of one layer of cells, papillose.*

Margin reflexed or undulate, entire.
Annulus 0 . . . . . **T. tophaceum, 1.**
Annulus large, compound . . . . . **T. pyriforme, 2.**
Margin plane or incurved.
Costa reaching apex or excurrent; serrate above.
Base of leaf yellowish, with thick walled rectangular cells . . . . . **T. crispulum, 3.**
Base of leaf hyaline.
Abruptly mucronate or obtuse, with long papillæ **T. flavo-virens, 4.**
Gradually acuminate, papillæ low . . **T. nitidum, Sch.**[1]
Costa ceasing far below apex; entire . . . **T. Coloradense.**[2]

II. *Lamina of two layers, upper surface mamillose, lower smooth.*

Peristome not twisted, seta arcuate or variously bent . **T. flexipes, 5.**
Peristone twisted, seta subflexuous . . . . **T. anomalum, 6.**

DESMATODON, p. 110.

I. *Capsule erect or nearly so.*

A. *Leaves without a hyaline or thickened border.*

1. *Not papillose* . , . . **D. systilius, 2.**

2. *Papillose.*

a. *Costa excurrent into a hair.*

Capsule oblong (1:2 or 1:3 excl. lid), 16 teeth divided nearly or quite to base.
Plants of mountainous regions; calyptra reaching base of capsule . . . . . **D. latifolius, 1.**
Plants of lowlands: calyptra reaching half way to base of capsule . . . . . **D .Guepini, 10.**

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[1] Renauld and Cardot: *Bot. Gaz.* xiv (1889), 99.
[2] Appendix, p. 413

Capsule cylindric (1:5-6); teeth divided half way or entire.

[D. obliquus may be sought here.]

Dioicous . . . . . **D. plinthobius, 6.**
Monoicous . . . . . **D. Neo-Mexicanus, 7.**

b. *Costa vanishing at apex or forming a short point.*

Leaves hyaline ¾ of their length . . . . . **D. obtusifolius, 9.**
Leaves hyaline only at base.
Margins revolute.
Capsule long cylindric, leaves crenulate . . **D. arenaceus, 3.**
Capsule elliptic, leaves entire . . . . . **D. nervosus, 8.**
Margins inflexed above . . . . . **D. Garberi, 4.**

B. *Leaves with a pellucid border.* . . **D. Porteri, 5.**

II. *Capsule nodding or pendent.*

Leaves with a thickened border below.
Seta straight, capsule nodding or horizontal . . **D. cernuus, 11.**
Seta reflexed, capsule pendent . . . . . **D. Laureri, 13.**
Leaves without a border . . . . . **D. obliquus, 12.**

BARBULA, p. 115.

I. *Leaves with jointed dichotomous filaments on the costa.*

Costa broad (½ leaf) flattened, leaves thick, rigid . . **§ I. Aloidellæ.**
Costa narrow, round, leaves thin, broad . . . **§ II. Chloronotæ.**

II. *Leaves not filamentose.*

Teeth from a low membrane, scarcely projecting from the mouth [excl. *B. brevipes*].
Plants small.
Leaf cells distinct . . . . . **§ III. Cuneifoliæ.**
Leaf cells small.
Perichætial leaves little different from the foliage, **§ IV. Unguiculatæ.**
Perichætial leaves long sheathing or convolute . **§ V. Convolutæ.**
Plants robust [excl. *B. cæspitosa*].
Leaves entire; stems radiculose . . . . . **§ VI. Tortuosæ.**
Leaves serrate, stems not radiculose . . . **§ VII. Squarrosæ.**
Teeth from a high tesselated membrane . , **§ VIII. Syntrichiæ.**

§ I. Aloidellæ.

Synoicous . . . . . **B. brevirostris, 1.**
Dioicous.
  Annulus broad, revoluble, calyptra reaching the middle of the capsule . . . . . **B. rigida, 2.**
  Annulus small, persistent, calyptra barely covering the lid . . . . . **B. ambigua, 3.**

§ II. Chloronotæ.

Leaves with hair points.
  Tip of leaf hyaline . . . . . **B. membranifolia, 4.**
  Tip of leaf concolorous.
    Hair smooth, leaves acute or somewhat obtuse . **B. chloronotos, 5.**
    Hair serrate, leaves rounded obtuse . . . . **B. Henrici.**[1]
Leaves without hair points . . . . . **B. Manniæ.**[2]

§ III. Cuneifoliæ.

Leaves bordered by 2–4 rows of thickened cells . . **B. marginata, 8.**
Leaves bordered by 1 row of round yellowish cells with prominent papillæ, aristate . . . . **B. Vahliana, 7.**
Leaves with a broad yellowish border, not pointed **B. Egelingi** Schliep.[2]
Leaves without a border.
  Costa excurrent into a hoary hair . . . . **B. muralis, 12.**
  Costa forming a short point or ceasing below apex.
    Leaf cells smooth . . . . . **B. cuneifolia, 6.**
    Leaf cells papillose [incl. *B. amplexa ?*]
      Peristome membrane long . . . . . **B. brevipes, 11.**
      Peristome membrane short.
        Inner perichætial leaves short . . . **B. Bolanderi, 9.**
        Inner perichætial leaves long-sheathing, abruptly reflexed . . . . . **B. amplexa, 10.**

§ IV. Unguiculatæ.

[**B. cæspitosa** may be sought here.]

I. *Peristome 0.* . . . . . **B. rubiginosa, 28**

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[1] Rau: *Bull. Washb. Coll. Lab.* 1 (1886). 172.
[2] Müller: *Flora* 1887, 222.

II. *Peristome present.*

A. *Teeth straight or scarcely twisted.*

Nodose, separate . . . . . **B. rigidula, 22.**
Cancellate . . . . . **B. cancellata, 19.**

B. *Teeth plainly twisted.*

1. *Leaves blunt or mucronate by the excurrent costa.*

Leaves short, ovate, the very apex obtuse.
Capsule cylindric, calyptra reaching middle . **B. brachyphylla, 20.**
Capsule ovate, calyptra reaching base . . . **B. purpurea, 21.**
Leaves longer, narrower, sharp pointed.
Cells at base rectangular and pellucid.
Capsule oblong-elliptic to sub-cylindric, sub-incurved, **B. unguiculata, 13.**
Capsule oblong, small, erect . . . . . **B. Jooriana, 14.**
Cells at base quadrate, chlorophyllose . . . **B. Cruegeri, 18.**

2. *Leaves gradually pointed.*

a. *Leaves not papillose* [incl. *B. artocarpa ?*]

Annulus none . . . . . **B. gracilis, 31.**
Annulus large, simple, persistent . . . . . **B. artocarpa, 30.**

b. *Leaves papillose.*

i. *Cells at base roundish, quadrate or short- rectangular.*

Annulus 0.
Costa 70 μ wide at base and tapering gradually . **B. fallax, 15.**
Costa 50 μ wide, of equal breadth to middle . **B. recurvifolia, 17.**
Annulus pale, compound . . . . . **B. elata, 27.**

ii. *Cells at base rectangular, often elongated.*

[**B. fallax** may be sought here.]

Leaves erect-incurved, imbricate when dry.
Cells above 5–7 μ diameter . . . . . **B. vinealis, 23.**
Cells twice as large . . . . . **B. virescens, 25.**
Leaves squarrose-spreading or reflexed, twisted when dry.
Perichætial leaves open, sheathing only at base, revolute on edges . . . . . **B. subfallax, 16.**
Perichætial leaves half sheathing.
Annulus simple, narrow, persistent . . . **B. semitorta, 29**[1].

[1] In Lesq. & James' Manual, p. 126, in note under *B. semitorta*, read "Comparable to *B. vinealis*" instead of B. brachyphylla. See *Pacif. R. R. Rept.*, iv, 186.

Annulus double or triple.

Cells 5–7 μ in diameter . . . . . { **B. cylindrica, 26.** / **B. flexifolia, 24.**

Cells twice as large . . . . . **B. virescens, 25.**

Nos. 23, 24, 25, 26, with possibly 29, are doubtless forms of one species, so that the key will probably break down here.

§ V. Convolutæ.

Leaves involute on margin.

Aristulate by excurrent costa . . . . . **B. agraria, 34.**

Acute or submucronate . . . . . **B. Donnellii, 36.**

Leaves plane on margin or recurved.

Capsule costate when dry . . . . . **B. Raui, 35.**

Capsule smooth.

Leaves acute, costa percurrent . . . . . **B. convoluta, 32.**

Leaves with hyaline point . . . . . **B. Closteri, 33.**

§ VI. Tortuosæ.

Leaves long linear, acute, abruptly mucronate . . **B. cæspitosa, 37.**

Leaves very long acuminate, cuspidate.

Twisted crispate when dry, above of one layer of cells **B. tortuosa, 38.**

Not crispate, brittle, two layers of cells above . . **B. fragilis, 39.**

§ VII. Squarrosæ.

Includes but one species . . . . . **B. squarrosa, 40.**

§ VIII. Syntrichiæ.

[**B. brevipes** may be sought here.]

I. *Leaves with a border of thickened cells.*

Marginal cells elongated . . . . . **B. subulata, 41.**

Marginal cells roundish . . . . . **B. lævipila, 44.**

II. *Leaves not bordered.*

Cells smooth . . . . . **B. mucronifolia, 43.**

Cells papillose.

Monoicous.

Costa percurrent . . . . . { **B. inermis, 42.** / **B. subulata var. mutica, 41.**

Costa excurrent into a long (mostly smooth) hyaline hair . . . . . **B. lævipila, 44.**

Polygamous, costa excurrent into a hyaline spinulose hair **B. Muelleri**, 48.
Dioicous.
Costa percurrent or ceasing below apex . . . **B. latifolia**, 45.
Costa short-excurrent, clothed above with gemmæ **B. papillosa**, 47.
Costa naked, excurrent into a hyaline, spinulose hair.
Hair red at base, upper leaves acute . . **B. megalocarpa.**[1]
Hair white throughout, upper leaves rounded or emarginate . . . . . **B. ruralis**, 46.

GRIMMIA, p. 134.

Seta shorter than the capsule.
Straight, capsule symmetric.
Lid falling with columella . . . . . **§ I. Schistidium.**
Lid persistent on columella . . . . . **§ II. Scouleria.**
Crooked, capsule ventricose . . . **§ III. Gasterogrimmia.**
Seta longer than capsule.
Arcuate . . . . . **§ IV. Eugrimmia.**
Straight . . . . . **§ V. Guembelia.**

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§ I. Schistidium.

Leaves with hyaline points (excl. vars. of 1 and 3)
Perichætial leaves obtuse, in lower ⅔ cells large . **G. platyphylla**, 4.
Perichætial leaves hair pointed.
Capsule oblong . . . . . **G. ambigua**, 2.
Capsule ovate-globose.
In small dense cushions, soft, lurid green . **G. conferta**, 1.
In lax cushions, coarse, fuscescent . . . **G. apocarpa**, 3.
Leaves muticous.
Margins plane.
Coarsely dentate at apex . . . . . **G. Agassizii**, 5.
Entire at apex . . . . . **G. maritima**, 6.
Margins recurved or revolute . . . . . { **G. conferta** / **G. apocarpa** } vars.

§ II. Scouleria.

Includes but one species . . . . . **G. Scouleri**, 7.

§ III. Gasterogrimmia.

Peristome 0, lamina bistratose near apex . . . . **G. anodon**, 8.
Peristome present, lamina unistratose throughout . **G. plagiopoda**, 9.

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[1] Kindberg: *Bull. Torr. Bot. Club*, xvi (1889), 92.

§ IV. Eugrimmia.

Capsule costate when dry.
- Leaves homomallous-falcate when dry . . . . **G. hamulosa, 12.**
- Leaves spirally twisted on stem when dry . . **G. torquata, 13.**
- Leaves incurved-cirrhate when dry . . . . . **G. contorta, 11.**
- Leaves imbricate or slightly twisted when dry.
  - Hair point rough, capsule obscurely costate . **G. Muhlenbeckii, 14.**
  - Hair point smooth, capsule strongly costate.
    - Laxly pulvinate-cespitose, dioicous . . **G. trichophylla, 16.**
    - Densely pulvinate, monoicous . . . . . **G. pulvinata, 10.**

Capsule not costate (or obscurely) when dry.
- Leaves falcate-reflexed when moist . . . . . **G. Watsoni, 15.**
- Leaves not reflexed.
  - Margins plane, capsule elliptic, collum 0 . . . . **G. Olneyi, 17.**
    [**G. Muhlenbeckii** may be sought here].
  - Margins reflexed.
    - Capsule subpyriform, collum distinct, leaves not gemmiferous . . . . . **G. Californica, 18.**
    - Capsule oval-oblong, upper leaves gemmiferous **G. Hartmani, Sch.**[1]

A sterile species, *Grimmia arcuatifolia*, probably belonging to this section has been described by Kindberg in *Bull. Torr. Bot. Club*, xvi (1889), 93. It resembles G. Watsoni in the reflexed leaves.

§ V. Guembelia.

Lamina above 2-4 stratose.
- Calyptra cucullate.
  - Leaves hair pointed . . . . . **G. commutata, 25.**
  - Leaves not hair pointed, rather blunt . . . . **G. unicolor, 28.**
- Calyptra mitrate.
  - Leaf margins plane . . . . . **G. leucophæa, 22.**
  - Leaf margins recurved.
    - Walls of basal cells sinuate . . . . **G. Pennsylvanica, 23.**
    - Walls of basal cells smooth . . . . . **G. ovata, 21.**

Only the margin 2—4-stratose.
- Leaves muticous or hyaline, apiculate . . **G. Coloradensis, 20.**
- Leaves hair pointed.
  - Annulus 0.
    - Calyptra mitrate, covering whole capsule . **G. calyptrata, 23.**
    - Calyptra cucullate . . . . . **G. montana, 26.**

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[1] Mrs. E. G. Britton, *Bull. Torr. Bot. Club*, xvi (1889), 340.

Annulus present.
Cells of leaf base elongated (1:4 to 1:8) . . **G. Donniana, 19.**
Cells of leaf base short (1:2) . . . . . **G. alpestris, 27.**

Grimmia Manniæ, apparently of this section, is described by Müller (*Flora* 1887, 228), from California. Mrs. E. G. Britton is of opinion that it is only *G. alpestris* Schleich.

RHACOMITRIUM, p. 147.

I. *Branches fastigiate.*

Leaves with a short hyaline point . . . . . **R. Sudeticum, 5.**
Leaves muticous.
Costa with 2–4 lamellæ at back . . . . . **R. patens, 1.**
Costa not lamellose.
Leaves with large quadrate cells at the basal angles, decurrent . . . . . **R. depressum, 3.**
Leaves not auricled nor decurrent.
Obtuse.
Perichætial leaves costate, seta long . **R. aciculare, 2.**
Perichætial leaves ecostate, seta short . . **R. Nevii, 4.**
Acute . . . . . **R. Macounii,** [1].

II. *Branches fasciculate.*

A. *Leaves muticous.*

Cells elongated above. . . . . **R. fasciculare, 7.**
Cells quadratic above . . . . . **R. varium, 8.**[2]
[R. canescens may be sought here.]

B. *Leaves with a hyaline point.*

Cells linear throughout lamina . . . . . **R. microcarpum, 9.**
Cells quadratic above.
Strongly papillose both sides . . . . . **R. canescens, 11.**
Smooth (except at the point).
Hyaline point denticulate . . . . . **R. heterostichum, 6.**
[R. canescens var. lutescens and R. varium may be sought here.]
Hyaline point strongly erose-serrate and papillose **R. lanuginosum, 10.**

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[1] Kindberg: *Bull. Torr. Bot. Club*, xvi (1889), 93.

[2] R. Oreganum Renauld and Cardot: *Bot. Gaz.*, xiii (1888), 198, pl. XV, is this species (*fide* J. Cardot *in litt.*), which seems to be *R. canescens*, var. *lutescens* L. and J.; *fide* Mrs. E. G. Britton *in litt.*

COSCINODON, p. 154.

Costa not entering the hyaline point which is less than the leaf in length.
- Dioicous, leaves oblong lanceolate . . . . . **C. pulvinatus, 1.**
- Autoicous, leaves obovate . . . . . **C. Raui, 3.**

Costa forming a rough hyaline point twice as long as the leaf . . . . . **C. Wrightii, 2.**

PTYCHOMITRIUM, p. 156.

Plants large (3 cm. +), leaves acuminate, sharply dentate **P. Gardneri, 1.**

Plants small (1 cm. —), leaves not acuminate, nearly or quite entire.
- Collum 0.
  - Teeth subulate (1:10), entire . . . . . **P. incurvum, 2.**
  - Teeth lanceolate (1:4), bi- or trifid . . . **P. Drummondii, 3.**
- Collum equalling one-third sporangium . . . **P. pygmæum, 4.**

AMPHORIDIUM, p. 158.

Leaf margins plane, entire . . . . . **A. Lapponicum, 1.**

Leaf margins recurved or revolute.
- Leaves remote, recurved-spreading, serrate . **A. Sullivantii, 4.**
- Leaves close.
  - Costa excurrent, seta arcuate . . . . . **A. Californicum, 3.**
  - Costa vanishing below apex.
    - Entire . . . . . **A. Mougeotii, 2.**
    - Serrulate . . . . . **A. cæspitosum, 5.**

ULOTA, p. 160.

I. *Leaves rigid, not crispate when dry.*

[**U. Drummondii** may be sought here.]

- Costa percurrent . . . . . **U. Hutchinsiæ, 9.**
- Costa ceasing below apex . . . . . **U. Barclayi, 10.**

II. *Leaves crispate when dry.*

Upper leaves tipped with gemmæ . . . **U. phyllantha, 8.**

Upper leaves not bearing gemmæ.
  Dry capsule costate only at narrow mouth . . **U. Ludwigii**, 2.
  Dry capsule costate its whole length.
    Stems creeping, leaves slightly crispate, peristome simple . . . . . **U. Drummondii**, 1.
    Stems not creeping, leaves strongly crispate, peristome double.
      Mouth of capsule contracted . . . . . **U. Bruchii**, 4.
      Mouth of capsule not contracted.
        Tufts brown, on rocks . . . . . **U. curvifolia**, 3.
        Tufts green, on trees.
          Capsule contracted below the mouth . . . **U. crispa**, 5.
          Capsule not contracted below the mouth . **U. crispula**, 7.

U. Americana of Mitten (no. 6), is allied to the last two species, and I am unable to see wherein it differs in any features which can be used in a key.

ORTHOTRICHUM, p. 164.

I. *Leaves obtuse.*

Margins plane, stomata superficial . . . . . **O. obtusifolium**, 31.
Margins revolute.
  Peristome simple, on rocks . . . . . **O. Jamesianum**, 32.
  Peristome double, in water . . . . . **O. rivulare**, 30.

II. *Leaves with hyaline points.*

Plants large (7–8 cm.) . . . . . **O. Pringlei**, [1].
Plants smaller (about 1 cm.).
  Teeth equidistant, cilia of 1 row of cells . . **O. diaphanum**, 28.
  Teeth bigeminate, cilia of 2 rows of cells . . . **O. canum**, 29.

III. *Leaves acute, without hyaline points, margins revolute or recurved.*

A. *Stomata superficial.*

1. *Peristome simple.*

[**OO. Texanum** and **rupestre** may be sought here.]

Capsule wholly exserted, smooth when dry.
  Defluent into seta . . . . . **O. lævigatum**, 2.
  Abrupt at base . . . . . **O. Douglasii**, 6.

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[1] Müller: *Bull. Torr. Bot. Club.*, xiii (1886), 120. But July 18, 1888, he writes: "Mein O. Pringlei ist forma longifolia crispata papillosa von *O. Lyellii*, und anderer mal *O. papillosum* und *O. Pacificum* Hampe"! —*fide* Mrs. E. G. Britton.

Capsule immersed or emergent.
  Leaves densely papillose . . . . . **O. Sturmii, 4.**
  Leaves almost smooth . . . . . **O. bullatum,** [1].

2. *Peristome double.*

[**OO. lævigatum** and **Sturmii**, may be sought here.]

a. *Capsule entirely smooth.*

Immersed, papillæ simple . . . . . **O. leiocarpum, 25.**
Exserted, papillæ bifurcate . . . . . **O. Kinglanum, 15.**

b. *Capsule strongly costate.*

Leaves beset with clavate gemmæ . . . . . **O. Lyellii, 33.**
Leaves not gemmiferous.
  Teeth erect when dry, cilia 16 . . . . . **O. Texanum, 5.**
  Teeth reflexed when dry (O. brachytrichum ?), cilia 8.
    Capsule (incl. collum) subcylindric.
      Leaves acute, papillæ simple or bifurcate, salient . **O. affine, 10.**
      Leaves apiculate, minutely papillose . . **O. brachytrichum, 18.**
    Capsule obovate . . . . . **O. sordidum, 14.**

c. *Capsule ribbed only near mouth.*

Peristome opaque, very papillose, reflexed when dry **O. speciosum, 12.**
Peristome opaque, transversely lineolate, reflexed when dry . . . . . **O. Bolanderi, 8.**[2]
Peristome not opaque, erect when dry, papillæ more or less obliterated or reduced to sinuous lines . . **O. rupestre, 7.**

B. *Stomata immersed.*

1. *Peristome simple.*

Capsule smooth when dry . . . . . **O. Douglasii, 6.**[3]
Capsule faintly costate, bands (8, rarely 16) cinnamon-red **O. anomalum, 1.**
Capsule 16-costate, bands (16, rarely 8) yellow . . **O. cupulatum, 3.**
Capsule 8-costate . . . . . **O. Texanum, 5.**[3]

[**O. Hallii** may be sought here.]

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[1] Müller: *Flora*, 1887, 223.

[2] This sp. is *O. rupestre*, var. *vulgare*, forma *densior* according to Venturi in Husn. *Musc. Gall.* 156.

[3] This species is repeated here because the character of the stomata is unknown to me.

2. *Peristome double.*

a. *Capsule smooth when dry.*

Cilia wider than teeth . . . . . **O. exiguum, 24.**
Cilia narrow.
  Capsule gradually narrowed to seta . . . . . **O. pallens, 26.**
  Capsule abruptly contracted to seta . . . . **O. psilocarpum, 23.**

b. *Capsule costate when dry.*

i. *Abruptly contracted to seta, collum not evident.*

Leaves with simple papillæ.
  Capsule exserted, teeth papillose , ... **O. consimile, 21.**
  Capsule subimmersed, teeth with oblique sinuous lines . **O. Hallii, 13.**
Leaves rough with very long forked papillæ . . . **O. Watsoni, 9.**

ii. *Gradually narrowed to seta with evident collum.*

* *Capsule exserted.*

[O. tenellum may be sought here.]

  Cilia 8, calyptra hairy . . . . . **O. cylindricarpum, 22.**
  Cilia 16, calyptra naked . . . . . **O. pulchellum, 27.**

* * *Capsule immersed or nearly.*

Leaves with salient furcate papillæ.
  Teeth papillose below, paler above, with longitudinal or sinuous lines, rarely perforate . . . . . **O. alpestre, 11.**
  Teeth papillose throughout, often perforate along median line.
    Neck of capsule shriveling into a cup which receives the seta, capsule contracted below mouth . . . . **O. fallax, 17.**
    Neck of capsule not becoming cupped, capsule not contracted below mouth . . . . . **O. pumilum, Sw.**[1]
Leaves with simple, often weak papillæ.
  Capsule emergent, subcylindric (long cyl. when dry), little contracted below the mouth . . . . **O. tenellum, 20.**
  Capsule immersed, obovate, contracted below mouth.
    Neck shrivelling into a cup, which receives the seta . **O. fallax, 17.**
    Neck not becoming cupped . . . . . **O. strangulatum, 19.**
  Capsule immersed, not contracted.
    Capsule straw-colored, teeth dirty-reddish . . **O. Ohioense, 16.**
    Capsule with yellow (not orange) bands, teeth orange, yellow or pale . . . . . **O. pumilum Sw.**[1]

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[1] Venturi: Husn. *Musc. Gall.* 179, pl. 49.

MACROMITRIUM, p. 178.

Capsule plicate at mouth and base only . . . . **M. Sullivantii,** 1
Capsule costate its whole length.
  Lid conic, blunt, peristome 0. . . . . **M. Fitzgeraldi,** 2
  Lid subulate, peristome present . . . . **M. rhabdocarpum,** 3
Capsule smooth . . . . . **M. mucronifolium,** 4

ENCALYPTA, p. 180.

I. *Capsule spirally striate and sulcate when dry.*

Capsule twisted to the right when dry, leaves with hyaline hair points, teeth glabrous . . . . . **E. Selwyni,** 1
Capsule twisted to the left when dry.
  Leaves acute or apiculate, teeth papillose, with a median line . . . . . **E. procera,** 6
  Leaves muticous, usually obtuse, teeth filiform, nodose, minutely papillose . . . . . **E. streptocarpa,** 8

II. *Capsule vertically striate and sulcate when dry, or smooth.*

Distinctly striate . . . . . **E. rhabdocarpa,** 3
Smooth or faintly striolate.
  Calyptra entire at base, peristome 0 or fugacious.
    Calyptra smooth at apex . . . . . **E. commutata,** 1
    Calyptra scabrous at apex . . . . . **E. vulgaris,** 2
  Calyptra fringed at base, peristome present.
    Leaves apiculate-acuminate . . . . . **E. ciliata,** 4
    Leaves muticous . . . . . **E. Macounii,** 5

CALYMPERES, p. 184.

Leaves oblong or broad-ovate.
  Upper leaves very obtuse, often filamentose at apex . **C. Richardi.**
  Upper leaves acute, often filamentose in middle . **C. disciforme,**
Leaves narrowly panduriform, obtuse or retuse . **C. (?) crispum.**

SYRRHOPODON, p. 185.

Leaf margins bilamellate upwards . . . . . **S. Floridanus.**
Leaf margins single throughout . . . . . **S. Texanus.**

TETRAPHIS, p. 186.

Pedicel straight . . . . . **T. pellucida, 1.**
Pedicel geniculate at middle . . . . . **T. geniculata, 2.**

DISSODON, p. 189.

Seta short (5 mm.), thick, capsule erect, chestnut brown, **D. Hornschuchii, 1.**
Seta longer (1.5 cm.), plants 1–2 cm. high, capsule often inclined, orange . . . . . **D. Froelichianus, 2.**
Seta longer (3–4 cm.), plants 4–12 cm., capsule erect, orange . . . . . **D. splachnoides, 3.**

TAYLORIA, p. 190.

Teeth ¼ length of sporangium, strap-like, reflexed, sinuous and twisted when dry, upper half of leaf serrate, **T. splachnoides, 2.**
Teeth much shorter, linear, recurved, upper third of leaf serrate . . . . . **T. serrata, 1.**

TETRAPLODON, p. 191.

Leaves sharply serrate, narrowed to filiform point . **T. angustatus, 1.**
Leaves distantly incised-serrate, gradually acuminate . **T. australis, 3.**
Leaves entire, more or less abruptly filiform-apiculate.
. Costa sub-excurrent, empty sporangium constricted in middle . . . . . **T. mnioides, 2.**
Costa ceasing below point, empty sporangium not constricted in middle . . . . . **T. urceolatus, 4.**

SPLACHNUM, p. 193.

Apophysis ovate or subglobose.
About the size of the sporangium.
Costa excurrent, apophysis red . . . . . **S. sphæricum, 2.**
Costa ceasing below apex, apophysis at first green then brown . . . . . **S. Wormskioldii, 1.**
Greatly exceeding the sporangium . . . . **S. vasculosum, 3.**
Apophysis pyriform, exceeding the sporangium . **S. ampullaceum, 4.**
Apophysis campanulate.
Purple . . . . . **S. rubrum, 5.**
Yellow . . . . . **S. luteum, 6.**

PHYSCOMITRIUM, p. 196.

Capsule immersed . . . . . **P. immersum, 1.**
Capsule exserted.
  Leaves entire or nearly so.
    Seta short, little exceeding leaves . . . . . **P. Hookeri, 4.**
    Seta much longer (5–10 mm.)
      Leaves ovate-lanceolate, collum distinct . **P. acuminatum, 5.**
      Leaves linear-lanceolate, collum 0 . . **P. turbinatum, 6.**
  Leaves serrate, cells at mouth of capsule transversely elongate.
    5–7 rows . . . . . **P. pygmæum, 2.**
    12–15 rows [P. megalocarpum?]
      Leaves more or less acuminate, distinctly yellow-bordered . . . . . **P. megalocarpum.**[1]
      Leaves acute, not bordered . . . . . **P. pyriforme, 3.**

ENTOSTHODON, p. 199.

Leaves acute, capsule short-pyriform.
  Costa percurrent, teeth dark red, striolate . . **E. Drummondii, 1.**
Leaves acuminate, capsule long-pyriform.
  Costa reaching middle, teeth whitish, granulose . **E. Bolanderi, 2.**
  Costa subpercurrent, teeth red, nodose, papillose . **E. Templetoni, 3.**

FUNARIA, p. 200.

Annulus 0.
  Leaves entire or nearly.
    Capsule arcuate, leaves acuminate
      Costa excurrent . . . . . **F. Americana, 1.**
      Costa vanishing . . . . . **F. Mediterranea, 2.**
    Capsule erect, leaves acute . . . . . **F. Californica, 5.**
  Leaves sharply serrate.
    Short-pointed, lid convex, mamillate . . . . . **F. serrata, 4.**
    Long acuminate, lid short conic . . . . . **F. calcarea, 3.**
Annulus large, revoluble.
  Capsule irregularly plicate and furrowed.
    Leaves with involute margins . . . . . **F. convoluta, 6.**
    Leaves with plane margins . . . . . **F. flavicans, 7.**
  Capsule distinctly striate-costate.
    Leaves short-acuminate, lid large, spores 12–17 μ **F. hygrometrica, 8.**
    Leaves long acuminate, lid small, spores 24–28 μ **F. microstoma, 9.**

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[1] Kindberg: *Bull. Torr. Bot. Club*, xvi (1889,) 94.

BARTRAMIA, p. 203.

Capsule erect, peristome 0 or simple.
  Leaves reflexed on margin below, capsule rugose when dry . . . . . **B. Menziesii, 1.**
  Leaves plane, capsule plicate-furrowed . . . **B. subulata, 2.**
  Leaves plane, capsule ribbed . . . . . **B. stricta, 3.**
Capsule curved, lid oblique, peristome double.
  Seta short (= capsule), fruit pseudo-lateral . . **B. Halleriana, 7.**
  Seta exceeding stems.
    Leaves smooth . . . . . **B. Œderiana, 5.**
    Leaves papillose only on upper surface . . . **B. radicalis, 8.**
    Leaves papillose on both surfaces.
      Base white, margin plane; synoicous . . **B. ithyphylla, 4.**
      Base not white, margin revolute; autoicous . **B. pomiformis, 6 .**

PHILONOTIS, p. 208.

Leaf cells quadrate . . . . . **P. Macounii, 2.**
Leaf cells rectangular to linear.
  Plants short (1–3 cm.).
    Costa thick, rusty, leaves erect-spreading, capsule horizontal . . . . . **P. Muhlenbeckii, 1.**
    Costa canaliculate, leaves closely appressed, capsule oblique . . . . . **P. Mohriana, 5.**
  Plants usually long (3–15 cm.).
    Mouth of capsule with 8 rows of transversely elongated cells . . . . . **P. fontana, 3.**
    Mouth of capsule with 4 rows . . . . . **P. calcarea, 4.**

MEESIA, p. 212.

Leaves entire, margins reflexed or revolute.
  Synoicous, costa very thick (⅓ leaf base) . . . **M. uliginosa, 1.**
  Autoicous, costa narrow (¼ leaf base) . . . **M. Albertinii, 3.**
Leaves entire, margins plane . . . . . **M. longiseta, 2.**
Leaves serrate . . . . . **M. tristicha, 4.**

WEBERA, p. 215.

I. *Leaves with a reddish border, distinct to apex* . **W. Tozeri, 17.**

II. *Leaves not bordered, or indistinctly.*

A. *Annulus present.*

1. *Segments and cilia of endostome imperfect, often only a laciniate membrane* . . . . . **W. camptotrachela.**[1]

2. *Segments of endostome not widely open along the keel, cilia 0 or short* (excl. *W. longicolla*).

Inflorescence autoicous . . . . . **W. acuminata, 1.**
Inflorescence synoicous or dioicous.
Costa very broad, ⅓–¼ of leaf base . . . . . **W. Cardoti, Ren.**[2]
Costa narrow.
Plants less than 1 cm., seta 5–8 mm., capsule wide-mouthed when dry . . . . . **W. nudicaulis, 11.**
Plants small, seta longer, mouth of capsule constricted when dry . . . . . **W. Bolanderi, 12.**
Plants 2 cm. or more, seta 2–3 cm. . . . . **W. cruda, 7.**
Inflorescence paroicous.
[**W. nudicaulis** may be sought here.]
Neck shorter than sporangium, cilia 0 . . . **W. polymorpha, 2.**
Neck equaling sporangium, cilia more or less developed.
Cilia ½ (or less) height of teeth . . . . . **W. elongata, 3.**
Cilia equaling teeth . . . . . **W. longicolla, 4.**

3. *Segments of endostome split and gaping along keel, cilia well developed.*

Inflorescence paroicous.
Capsule pendent, touching seta, not contracted under mouth . . . . . **W. cucullata, 6.**
Capsule horizontal or pendent, not touching seta, contracted below mouth . . . . . **W. nutans, 5.**
Inflorescence dioicous.
Upper leaves lance-linear (1:8–10).
Plants loosely cespitose, in wet soil, 1 cm. high, seta 1–2 cm. . . . . **W. Lescuriana, 14.**
Plants solitary or gregarious, sphagnicolous, 3–6 cm., seta 3–4cm. . . . . **W. sphagnicola, 8.**
Uppermost leaves lanceolate (1:4–6).
Costa reaching apex . . . . . **W. annotina, 9.**
Costa vanishing . . . . . **W. commutata, 13.**

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[1] Renauld & Cardot: *Bot. Gaz.* xiii. (1888), 199, pl. XVI.
[2] Renauld & Cardot: *Bot. Gaz.* xiv (1889), 95, pl. XIII.

B. *Annulus 0.*

Leaves nearly entire, cilia very short . . . **W. Drummondii, 10.**
Leaves nearly entire, cilia 3 . . . . . **W. Bigelovii, 19.**
Leaves sharply serrate.
  Stem red, leaves glaucous-green . . . . **W. albicans, 18.**
  Stem and leaves green.
    Teeth red . . . . . **W. carnea, 15.**
    Teeth yellow . . . . . **W. pulchella, 16.**

BRYUM, p. 223.

Upper leaf cells rhombic to hexagonal.
  Plants not from stolons.
    Cilia 0, or inappendiculate . . . . . **§ I. Cladodium.**
    Cilia 2–4, appendiculate . . . . . **§ II. Eubryum.**
  Plants from stolons . . . . . **§ III. Rhodobryum.**
Upper leaf cells linear (1:10–15) branches julaceous **§ IV. Anomobryum.**

§ I. Cladodium.

A. *Autoicous.*

Leaves broad (1:2), costa vanishing . . . **B. calophyllum, 10.**
Leaves ovate-lanceolate.
  Cilia long, smooth . . . . . **B. Brownii, 3.**
  Cilia 0, or rudimentary.
    Capsule symmetric, pyriform, collum about ½ sporangium.
      Leaves faintly bordered, slightly revolute . . **B. Warneum, 6.**
      Leaves very distinctly bordered, broadly revolute **B. Biddlecomiæ, 7.**
    Capsule usually unsymmetric, elongate, collum = sporangium . . . . . **B. uliginosum, 11.**

B. *Synoicous, or heteroicous.*

Costa long excurrent.
  Endostome attached to peristome.
    Spores verruculose . . . . . **B. arcticum, 1.**
    Spores smooth, about 30 μ . . . . . **B. pendulum, 4.**
    Spores smooth, scarcely 20 μ . . . . . **B. angustirete,** [1].
  Endostome free [2] . . . . . **B. inclinatum, 5.**
Costa short excurrent, or percurrent.
  Leaves not bordered . . . . . **B. Knowltoni,** [3].

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[1] Kindberg: *Bull. Torr. Bot. Club*, xvi (1889), 94.

[2] *B. stenotrichum*, Müller (*Flora* 1887, 219), will be sought here and I am unable to discover from the description alone any essential difference between it and B. inclinatum.

[3] Barnes: *Bot. Gaz.* xiv. (1889), 41.

Leaves bordered.
Teeth very short (scarcely 200 μ), articles 10–12 . **B. Labradorense,** [1].
Teeth much longer, articles about 20.
Costa excurrent, leaves reddish, margin scarcely revolute . . . . . **B. purpurascens, 2.**
Costa vanishing or barely excurrent, margin strongly revolute . . . . . **B. lacustre, 8.**

[**B. flexuosum** may be sought here.]

C. *Dioicous.*

Endostome adherent to peristome, cilia 0 . . . **B. flexuosum, 9.**
Endostome free, cilia single . . . . . **B. Californicum, 34.**

§ II. **Eubryum.**

A. *Synoicous.*

Costa not excurrent . . . . . **B. Oreganum, 18.**
Costa excurrent into a smooth point.
Margins recurved . . . . . **B. torquescens, 16.**
Margins plane . . . . . **B. microstegium B. & S.** [2].
Costa excurrent into a serrate point.
Leaves short pointed, decurrent
With a broad border . . . . . **B. bimum, 14.**
Without a border . . . . . **B. lonchocaulon, 15.**
Leaves long-cuspidate, not decurrent.
Not bordered, entire . . . . . **B. intermedium, 12.**
Not bordered, serrate at apex . . . . . **B. provinciale, 17.**
Bordered . . . . . **B. cirrhatum, 13.**

B. *Autoicous.*

Capsule horizontal or nodding, leaf margins revolute . **B. pallescens, 19.**
Capsule pendulous, leaf margins plane . . . **B. subrotundum, 20.**

C. *Dioicous.*

1. *Costa not excurrent, or when excurrent forming a short point only.*

a. *Leaves obtuse.*

Distant, broadly ovate or oblong, rounded . . **B. cyclophyllum, 35.**
Imbricate, narrower.
Dull olive green, margins strongly revolute . **B. Muhlenbeckii, 26.**
Yellowish-green or purplish, tips of branches crimsoned.
Cells polygonal, thick-walled . . . . . **B. miniatum, 27.**
Cells rhombic, subquadrate below . . . . . **B. Atwateriæ, 28.**

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[1] Philibert: *Revue Bry.*, 1887, 55.
[2] Renauld and Cardot: *Bot. Gaz.* xiv (1889), 99.

b. *Leaves pointed, costa percurrent or excurrent.*

i. *Capsule short* (1:2) *abrupt at base* . . . **B. atropurpureum, 22.**

ii. *Capsule longer* (1:3+) *tapering at base.*

* *Blood red to dark purple.*

Plant short (5–15 mm.) in small lax yellowish-green tufts . . . . . **B. erythrocarpum, 21.**
Plants longer (3–5 cm.) in large compact shining red or purplish tufts . . . . . **B. alpinum, 25.**

* * *Yellowish-brown.*

Slightly incurved.
  Constricted below mouth . . . . . **B. meesioides** [1].
  Not constricted . . . . . **B. pallens, 36.**
Symmetric.
  Strongly constricted below mouth.
    Stems about 1 cm. high . . . . . **B. turbinatum, 39.**
    Stems 4—10 cm. high. . . . . **B. Schleicheri, 40.**
  Slightly constricted below mouth.
    Leaf margins plane . . . . . **B. Sawyeri** [2].
    Leaf margin revolute.
      Quite entire . . . . . **B. acutiusculum** [3].
      Serrate at apex . . . . . **B. pseudotriquetrum, 38.**

c. *Leaves pointed, costa vanishing.*

Leaves closely appressed, imbricate . . . . **B. argenteum, 29.**
Leaves spreading, imbricate . . . . . **B. capillare, 31.**
Leaves spreading, distant . . . . . **B. Duvalii, 37.**

2. *Costa excurrent, leaves long-caspidate.*

a. *Capsule short* (1: 2 *or less.*)

Constricted between sporangium and collum . . **B. versicolor, 24.**
Not constricted between sporangium and collum . **B. coronatum, 23.**

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[1] Kindberg: *Bull. Torr. Bot. Club*, xvi (1889), 95.
[2] Renauld and Cardot: *Bot. Gaz.*, xiv (1889), 95.
[3] Müller: *Flora*, 1887, 220.

b. *Capsule longer* (1 : 3 +)

i. *Collum long* (½ *sporangium or more*).

Leaves strongly twisted when dry, abruptly pointed . **B. capillare, 31.**
Leaves erect and straight when dry.
Collum equalling sporangium . . . . . **B. obconicum, 33.**
Collum one-half the sporangium.
Capsule constricted below the mouth . . **B. cæspiticium, 30.**
Capsule not constricted . . . . . **B. Vancouveriense,** [1].

ii. *Collum short* (¼ *sporangium or less*). . **B. occidentale, 32.**

§ III. Rhodobryum.

Costa percurrent or vanishing, margins revolute below, collum short . . . . . **B. roseum, 41.**
Costa excurrent, margins revolute ⅔ to ¾, collum ½ sporangium, curved . . . . . **B. Ontariense** [2].

§ IV. Anomobryum.

Costa sub-excurrent . . . . . **B. concinnatum, 42.**
Costa vanishing below apex . . . . . **B. bullatum** [3].

Bryum hydrophyllum Kindberg [1] is a species "closely allied to B. pseudotriquetrum," but so imperfectly known (neither flowers nor capsule having been found), and so briefly characterized that I am unable to assign it to any place in the key.

ZIERIA, p. 240.

Costa vanishing, collum twice sporangium . . . . **Z. julacea, 1.**
Costa excurrent, collum = sporangium . . . . **Z. demissa, 2.**

MNIUM, p. 241.

I. *Leaves serrate.*

A. *Teeth of leaves single.*

Stems dendroid . . . . . **M. Menziesii, 21.**

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[1] Kindberg: *Bull. Torr. Bot. Club*, xvi (1889), 95.
[2] Kindberg: *Ottawa Nat.* ii (1889), 155 and l. c., p. 96.
[3] Müller: *Flora* 1887, 221.

Stems simple or branched, not dendroid.
  Basilar branches stoloniform.
    Leaves acuminate, serrate to middle, lid convex or mamillate, membrane of endostome lacunose **M. cuspidatum, 1.**
    Leaves acuminate, serrate to base.
      Lid apiculate . . . . . **M. medium, 4.**
      Lid mammiform . . . . . **M. affine, 7.**
    Leaves rounded at apex, mucronate, lid rostrate . **M. rostratum, 6.**
  Basilar branches erect, or stems simple.
    Capsule warty-papillose at base . . . . . **M. venustum, 3.**
    Capsule smooth at base.
      Perichætial leaves entire . . . . . **M. Nevii, 2.**
      Perichætial leaves toothed.
        Leaves nearly entire, not decurrent **M. affine, var. rugicum, 7.**
        Leaves serrate to base, long decurrent . . **M. insigne, 8.**
        Leaves serrate above, entire below.
          Border distinct, yellowish brown . . **M. Drummondii, 5.**
          Border 0 or faint . . . . . **M. stellare, 16.**

B. *Teeth of leaves in pairs.*

Costa vanishing just below apex . . . . . **M. hornum, 9.**
Costa percurrent.
  Capsules solitary.
    Synoicous . . . . . **M. serratum, 10.**
    Dioicous.
      Leaf-cells small, about 15 μ[1] . . **M. orthorrhynchum, 11.**
      Leaf-cells larger (20–30 μ ?)[2] . . . **M. lycopodioides, 12.**
      Leaf-cells very large (50–60 μ ?)[3] . . . **M. umbratile, 13.**
  Capsules clustered.
    Dioicous, leaves strongly crispate, capsule horizontal or inclined . . . . . **M. spinosum, 14.**
    Synoicous, leaves not crispate, capsule pendent **M. spinulosum, 15.**

II. *Leaves entire.*

Upper leaf-cells with long diameters oblique to costa.
  Leaves bordered.
    Costate to apex, dioicous, capsule oblong . **M. punctatum, 18.**
    Costa vanishing, synoicous, capsule subglobose **M. subglobosum, 19.**

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[1] *Fide* Husnot: *Musc. Gall.* 255.

[2] "Cellules un peu plus grandes," Husnot: *op. cit.*, 256. *M. riparium* Mitt. (*M. lycopodioides* Bry. Eu., *sec.* Mitten; *M. serratum* var. *riparium*, *sec.* Husnot, *l. c.*) has cells half as large as *M. umbratile* Mitt., *fide* Mitten: *Jour. Linn. Soc.* viii (1865), 30.

[3] Cells four times as large as M. orthorrhynchum, *fide* Mitten, *l. c.*

Leaves not bordered, costa vanishing, dioicous, capsule ovate-oblong . . . . . **M. cinclidioides, 17.**
Upper leaf-cells isodiametric, costa vanishing **M. hymenophylloides, 20.**

CINCLIDIUM, p. 249.

Leaf margin of 4–5 rows of cells, laminal cells irregularly disposed . . . . . **C. stygium, 1.**
Leaf margin of 2 rows of red cells, laminal cells in rows oblique to costa . . . . . **C. subrotundum, 2.**

AULACOMNIUM, p. 252.

Leaves coarsely serrate to middle, autoicous . **A. heterostichum, 5.**
Leaves serrulate near apex, acute or acuminate, dioicous.
Stem leaves long acuminate, very roughly papillose **A. papillosum, 4.**
Stem leaves acute.
Stems commonly prolonged and gemmiferous, male flowers terminal, gemmiform . . **A. androgynum, 1.**
Stems not commonly gemmiferous, male flowers discoid . . . . . **A. palustre, 2.**
Leaves entire, obtuse . . . . . **A. turgidum, 3.**

[The leaves of **A. palustre** are entire when young, but soon become erose crenulate.]

TIMMIA, p. 254.

Capsule irregularly plicate when dry, segments appendiculate . . . . . **T. Megapolitana, 1.**
Capsule costate at mouth when dry, segments not appendiculate . . . . . **T. Austriaca, 2.**

ATRICHUM, p. 255.

Costa lamellose on upper side only.
Lamellæ 2–6, entire, lamina with teeth on surface.[1]
Lamellæ 4–6 cells high.
Leaves acute, serrate for ¾ length . . . **A. undulatum, 1.**
Leaves bluntish, serrate above middle only.
Teeth double, aculeate . . . . . **A. angustatum, 2.**
Teeth single, short . . . . . **A. xanthopelma, 4.**
Lamellæ 9–13 cells high . . . . . **A. Selwyni, 3.**
Lamellæ 4–8, serrate . . . . . **A. Lesquereii, 5.**
Lamellæ 1–3, 1–3 cells high, lamina smooth . . **A. crispum, 6.**
Costa lamellose on both sides, lamina with longitudinal rows of teeth on back . . . . . **A. parallelum, 7.**

[1] Excluding A. xanthopelma?

OLIGOTRICHUM, p. 258.

Lamina and costa lamellose on both surfaces . . . **O. aligerum, 1.**
Costa only lamellose on upper surface . . . . . **O. Lyallii, 2.**

POGONATUM, p. 260.

I. *Plants simple, mostly short, leaves straight when dry.*

[**P. alpinum**, var. **simplex** will be sought here.]

Lamellæ with marginal cells smooth.
  Leaves entire . . . . . **P. brachyphyllum, 2.**
  Leaves serrate . . . . . **P. brevicaule, 1.**
Lamellæ with marginal cells papillose.
  Teeth of leaves very long, often reflexed, marginal cells of lamellæ subquadrate . . . . . **P. dentatum, 4.**
  Teeth moderate, 2 rows of marginal cells of lamellæ transversely rectangular . . . . . **P. capillare, 3.**

II. *Plants large* (4–15 *cm.*), *leaves twisted when dry.*

Leaves very long (1.5–2 cm.) short sheathing, lamellæ about 60 . . . . . **P. Macounii.**[1]
Leaves less than 1 cm., short sheathing, lamellæ about 30 (?)[2], strongly contorted when dry . . . **P. contortum, 5.**
Leaves and lamellæ as in 5 (?) subcrispate, abruptly pointed . . . . . **P. atrovirens, 6.**

III. *Plants usually robust* (4–15 *cm.*), *rarely small, often much branched above, leaves straight when dry.*

Capsule papillose, marginal cells of lamellæ round in section . . . . . **P. urnigerum, 7.**
Capsule smooth, marginal cells of lamellæ ovate in section **P. alpinum, 8.**

POLYTRICHUM, p. 263.

Leaves entire, margins inflexed.
  Obtuse at apex . . . . . **P. sexangulare,**[3] Flörke.

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[1] Kindberg: Polytrichum (Pogonatum) Macounii: *Bull. Torr. Bot. Club* xvi (1889), 96.
[2] As shown in *Sull. Icon. Musc. Suppl.*, pl. 42, ff. 5, 6.
[3] Kindberg: *Bull. Torr. Bot. Club* xvi. (1889), 96; Renauld & Cardot: *Bot. Gaz.*, xiv. (1889) 99.

Aristate at apex.
Awn colored, short.
Leaves spreading when moist, subrecurved . **P. juniperinum, 4.**
Leaves erect-open, strict . , ... **P. strictum, 5.**
Awn hyaline, long . . . . . **P. piliferum, 3.**
Leaves serrate.
Marginal cells of lamellæ like rest, oval, higher than broad in section.
Capsule ovate, obscurely angled, lid rostrate . . **P. gracile, 1.**
Capsule oblong, 4–6 angled, lid acutely conic . **P. formosum, 2.**
Marginal cells of lamellæ enlarged, broader than high (2: 1) . . . . . **P. Ohioense.**[1]
Marginal cells of lamellæ semilunar, with two prominent papillæ at corners . . . . . **P. commune, 6.**

FONTINALIS, p. 268.

I. *Perichætial leaves abruptly pointed, entire.*[2]

Leaves decurrent, teeth not lacunose . . . **F. Neo-Mexicana, 3.**
Leaves not decurrent, teeth lacunose . . . **F. Dalecarlica, 4.**

II. *Perichætial leaves rounded-obtuse, entire or lacerate.*

A. *Leaves of branches unlike stem leaves* . . . **F. Howellii.**[3]

B. *Leaves homomorphous.*[4]

1. *Leaf-cells long-linear* (1: 10 +).

Alar cells very large.
Leaves acute . . . . . **F. Sullivantii, 8.**
Leaves with very apex blunt or denticulate . . . **F. flaccida.**[5]

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[1] Renauld & Cardot: *Revue Bryol.* 1885, 11; also *Bot. Gaz.*, xiii, (1888), 199, pl. XVII.

[2] The fruit of *F. Californica* and *F. flaccida* has not yet been found. The latter will possibly fall here. Müller has also described imperfectly a sterile species, *F. maritima*, from Neah Bay, Wash. It is distinguished at once, he says, by the rigid branches and deeply carinate-canaliculate leaves. Having seen neither specimens nor figures I am unable to place it properly in the key.

[3] Renauld & Cardot: *Bot. Gaz.*, xiii (1888), 200, pl. XVIII.

[4] In *F. biformis* the summer leaves are unlike the vernal, so that specimens collected just as the vernal are falling might deceive.

[5] Renauld & Cardot: l. c., p. 201, pl. XIX.

Alar cells moderately enlarged.
  Capsule ovate to oblong.
    Leaves crowded . . . . . **F. Delamarei.**[1]
    Leaves loose or scattered.
      Perichætial leaves lacerate . . . . . **F. hypnoides, 11.**
      Perichætial leaves entire, undulate at tip . . **F. Lescurii, 7.**
  Capsule cylindrical.
    1:4, endostome perfect . . . . . **F. disticha, 10.**
    1:5.5, endostome imperfect . . . . . **F. filiformis, 9.**

2. *Leaf-cells rhombic-hexagonal* (1:6 *or less.*)

Plants shining with golden or coppery luster.
  Stems robust, little branched . **F. antipyretica var. gigantea, 1a.**
  Stems soft, much branched . . . . . **F. Californica, 2.**
Plants dull, yellowish to dirty green.
  Leaves with one edge reflexed near base . . **F. antipyretica, 1.**
  Leaves with margin plane.
    Female flowers abundant, in most leaf axils . **F. Novæ-Angliæ, 6.**
    Female flowers rare, at base of stems . . . **F. biformis, 5.**

DICHELYMA, p. 272.

Costa percurrent or vanishing.
  Capsule exceeding perichætium . . . . . **D. falcatum, 1.**
  Capsule not exceeding perichætium.
    Seta longer than capsule . . . . . **D. pallescens, 4.**
    Seta shorter than capsule . . . . . **D. subulatum, 5.**
  [Capsule unknown] . . . . . **D. Swartzii, 7.**
Costa excurrent.[2]
  Endostome a cancellate cone.
    Seta about 1 cm. long, capsule oval . . . **D. uncinatum, 2.**
    Seta 2—2.5 cm. long, capsule cylindric . **D. cylindricarpum, 6.**
  Endostome of appendiculate cilia, united only at the tips . . . . . **D. capillaceum, 3.**

CRYPHÆA, p. 275.

Costa percurrent or excurrent.
  Perichætial leaves costate . . . . . **C. nervosa, 3.**
  Perichætial leaves ecostate . . . . . **C. inundata, 5.**

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[1] Renauld & Cardot: *Bot. Gaz.* xiv (1889), 96, pl. XIV.

[2] Here belongs a sterile species, *D. longinerve* of Kindberg (*Bull. Torr. Bot. Club* xvi (1889), 97, which has the basal cells of leaves "numerous, in 4-6 rows, subquadrate, the alar greater, pellucid." He is not sure whether it is a Dichelyma or a Hypnum (§ Harpidium)! In which case it would better have been left undescribed!

Costa vanishing near middle.
  Costa of perichætial leaves excurrent into a thick point **C. glomerata, 1.**
  Costa of perichætial leaves vanishing in or below apex . **C. pendula, 2.**
  Costa of perichætial leaves vanishing far below apex . **C. Ravenelii, 4.**

LEPTODON, p. 278.

Leaves ecostate.
  Leaf cells not pitted, capsule 2 mm. long . . **L. trichomitrion, 1.**
  Leaf cells pitted, capsule 1 mm. long . . . **L. Floridanus, 1a.**
Leaves costate.
  Leaf cells round-oval, capsule exserted, oblong-oval . **L. Ohioensis, 2.**
  Leaf cells narrowly rhomboidal, capsule immersed, subglobose . . . . . **L. nitidus, 3.**

ALSIA, p. 279.

Annulus 0.
  Costa vanishing at middle (smooth?), margins reflexed **A. Californica, 1.**
  Costa vanishing near apex, dentate on back, margins plane . . . . . **A. longipes, 3.**
Annulus compound, revoluble, leaves papillose at back . **A. abietina, 2.**

NECKERA, p. 281.

Leaves very obtuse
  Plants slender (shoots 2 mm. wide), leaves loosely imbricate, rounded, concave . . . . . **N. disticha, 1.**
  Plants robust (shoots 4 mm. wide), leaves densely imbricate, truncate, not concave . . . . . **N. undulata, 2.**
Leaves rounded, abruptly apiculate.
  Revolute at base on one side, capsule immersed . **N. Menziesii, 3.**
  Not revolute, capsule exserted . . . . . **N. complanata, 7.**
Leaves acute or acuminate.
  Ecostate or nearly so.
    Capsule immersed or half exserted.
      Shoots obtuse . . . . . **N. pennata, 4.**
      Shoots attenuate to apex.
        Segments rudimentary, capsule immersed . **N. oligocarpa, 5.**
        Segments as long as teeth, capsule ½ exserted . **N. Douglasii, 6.**
    Capsule exserted . . . . . **N. pumila, 8.**
  Costate to the middle or beyond.
    Margins broadly revolute . . . . . , **N. Floridana, 9.**
    Margins not revolute.
      Alar cells fawn-color, costa thin, percurrent . **N. Ludoviciæ, 10.**
      Alar cells opaque, costa vanishing . . . **N. cymbifolia, 11.**

HOMALIA, p. 285.

Costa vanishing above middle, leaves serrulate.
  Leaves oblong, subfalcate, apiculate . . **H. trichomanoides, 1.**
  Leaves lingulate, subfalcate, apiculate . . . **H. Jamesii, 2.**
Costa sometimes hardly perceptible, leaves obovate, obtuse, serrulate . . . . . **H. obtusata, 3.**
Costa double, very short, or none, leaves entire . . **H. gracilis, 4.**

METEORIUM, p. 286.

Leaves serrulate . . . . . **M. pendulum, 1.**
Leaves minutely crenulate . . . . . **M. nigrescens, 2.**

LEUCODON, p. 287.

Capsule exserted.
  Leaves entire, open-erect, lid exactly conic . . **L. sciuroides, 1.**
  Leaves serrulate at apex, squarrose, lid obliquely rostrate . . . . . **L. julaceus, 2.**
Capsule surpassed by perichætial leaves, leaves secund **L. brachypus, 3.**

PTEROGONIUM, p. 289.

Leaves broadly oblong-ovate or -obovate, acute, smooth . **P. gracile, 1.**
Leaves broadly deltoid-ovate, narrowly acuminate, papillose . . . . . **P. brachypterum, 2.**

ANTITRICHIA, p. 290.

Capsule oval (1:2—2.5), leaf cells fusiform . . **A. curtipendula, 1.**
Capsule cylindric (1:6), leaf cells oval . . . . **A. Californica, 2.**

HOOKERIA, p. 292.

Leaves bicostate to middle (not papillose?) . . . . **H. varians, 1.**
Leaves bicostate to apex, papillose . . . . . **H. cruceana, 2.**
Leaves ecostate, entire (not papillose?) . . . . . **H. Sullivantii, 3.**

FABRONIA, p. 294.

Leaves ciliate-dentate.
  Peristome of 16 teeth, costa 0 or very short . . . . **F. pusilla, 1.**
  Peristome 0, leaves costate to middle . . **F. gymnostoma, 2.**
  Peristome of 8 geminate teeth, leaves costate nearly to middle . . . . . **F. octoblepharis, 3.**

Leaves serrate to subentire.
  Sharply serrate, teeth orange, spores about 11 μ . **F. Wrightii, 4.**
  Obscurely serrate, teeth brown, spores about 17 μ . **F. Ravenelii, 5.**
  Obscurely serrate, teeth with prominent articulations on back . . . . . **F. Donnellii, 6.**

THELIA, p. 298.

Papillæ of leaves simple.
  Horn shaped, curved . . . . . **T. hirtella, 1.**
  Globose . . . . . **T. robusta, 3.**
Papillæ 2—4-furcate.
  Usually bi-furcate, teeth 1:17—20 . . . . . **T. asprella, 2.**
  Usually 4-furcate, teeth 1:12 . . . . . **T. Lescurii, 4.**

MYURELLA, p. 300.

Leaves serrulate, obtuse (rarely short apiculate) . . **M. julacea, 1.**
Leaves serrulate, abruptly apiculate-acuminate . . **M. apiculata, 2.**
Leaves spinulose-dentate, abruptly long acuminate . **M. Careyana, 3.**

LESKEA, p. 302.

I. *Costa reaching to or beyond the middle.*

Percurrent . . . . . **L. nervosa, 3.**
Not percurrent.
  Leaves entire.
    Endostome divided into segments.
      Cleft between articulations, leaves bluntish . . **L. obscura, 2.**
      Not cleft, leaves acute . . . . . **L. polycarpa, 1.**
    Endostome a short undivided membrane . . . **L. Austini, 6.**
  Leaves crenulate . . . . . **L. tristis, 5.**

II. *Costa very short or none.*

Leaf cells linear-oblong . . . . . **L. denticulata, 4.**
Leaf cells rhombic.
  Leaves of primary stems acute . . . . . **L. pulvinata, 7.**
  Leaves of primary stems long acuminate . . . **L. Wollei, 8.**
Leaf cells round oval . . . . . **L. nigrescens**[1].

ANOMODON, p. 304.

Leaves not papillose . . . . . **A. Toccoæ, 6.**

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[1] Kindberg: *Ottawa Nat.* ii (1889), 155, and *Bull. Torr. Bot. Club* xvi (1889), 97.

Leaves papillose.
  Base with large fimbriate-papillose auricles.
    Margins reflexed near apex, replicate below middle **A. Californicus, 7.**
    Margins not at all reflexed . . . . . **A. apiculatus, 4.**
  Base not auriculate.
    Leaves filiform-acuminate . . . . . **A. rostratus, 1.**
    Leaves obtuse or apiculate.
      Branches attenuate . . . . . **A. attenuatus, 2.**
      Branches not attenuate.
        Leaves open-erect, teeth nodose . . . **A. obtusifolius, 3.**
        Leaves secund, teeth not nodose . . . **A. viticulosus, 5.**

PYLAISÆA, p. 308.

Segments free, split below, leaves quite entire.
  Plants glossy green . . . . . **P. polyantha, 1.**
  Plants pale yellowish green . . . . . **P. heteromalla, 2.**
Segments free, split throughout, leaves serrulate at apex, **P. subdenticulata, 3.**
Segments ½-adherent to teeth, spores 19—20 μ.
  Leaves long-acuminate, margin not recurved . . **P. intricata, 4.**
  Leaves short-acuminate, one or both edges recurved . **P. Selwyni,**[1].
Segments wholly adherent, spores 28 μ . . . . . **P. velutina, 5.**

HOMALOTHECIUM,[2] p. 309.

Costa short, simple or forking, vanishing below middle.
  Teeth red, operculum rostrate . . . . . **H. subcapillatum, 1.**
  Teeth yellow, operculum short apiculate . . . **H. corticolum,**[3].
Costa narrow, vanishing in point . . . **H. pseudosericeum, 2.**

CYLINDROTHECIUM, p. 310.

Capsules clustered (3 or 4) . . . . . **C. Floridanum, 4.**
Capsules solitary.
  Plants densely pinnately branched, leaves muticous **C. concinnum, 8.**
  Plants loosely pinnately branched, leaves pointed.
    Gradually narrowly acuminate . . . . . **C. brevisetum, 3.**

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[1] Kindberg: *Ottawa Naturalist* ii (1889), 156.
[2] Renauld & Cardot refer *Hypnum Nevadense* (30) to this genus. *Bot. Gaz.* xiii (1888) 202.
[3] Kindberg: l. c.

Acute or abruptly acuminate-apiculate.
Almost entire, only alar cells quadrate or rectangular.
Leaves acuminate-apiculate, teeth with 14—17 articulations, capsule 1: 3.5—4 . . **C. cladorrhizans, 1.**
Leaves abruptly short apiculate, teeth with 6—8 articulations, capsule 1: 5—5.5 . . . **C. seductrix, 2.**
Leaves not apiculate, teeth with 22—26 articulations, capsule 1: 2.5—3 . . . . . **C. compressum, 5.**
Distinctly serrulate, all basal cells rectangular.
Annulus 0, teeth obliquely striolate . **C. Drummondii, 6.**
Annulus large, teeth vertically striolate . **C. Sullivantii, 7.**

CLIMACIUM, p. 313.

Capsule straight, lid rostrate.
Ovate-oblong (1: 2.5—3), leaves slightly decurrent and hollowed at basal angles . . . . . **C. dendroides, 1.**
Cylindric (1: 5—6), leaves long decurrent and broadly auriculate . . . . . **C. Americanum, 2.**
Capsule arcuate, lid conic . . . . . **C. Ruthenicum, 3.**

ORTHOTHECIUM, p. 315.

Leaves lanceolate, long and narrowly acuminate . . **O. rufescens, 1.**
Leaves exactly ovate, apex flexuous, not plicate . . **O. rubellum, 2.**
Leaves lanceolate to ovate lanceolate, plicate, not acuminate . . . . . **O. chryseum, 3.**

HYPNUM, p. 316.[1]

I. *Leaves spreading.*

A. *Leaf cells short* (1:3 *or less.*)

1. *Leaves papillose.*

a. *Paraphyllia present.*

i. *Costa obsolete* . . . . . **H. dimorphum, 4.**

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[1] Nos. 2, 17, 18, 92, 93, 94, 114, 193, 194 and 195, are not included in this key. No. 2 is not North American, the locality cited by Schimper being York (Eng.), not *New* York. (Cf. A. Gepp in *Jour. Bot.* xxvii (1889), 152). The remainder are characterized by Lesquereux and James as of uncertain relationship or insufficiently known. No. 30 has been declared by Renauld and Cardot (*Bot. Gaz.* xiii (1889), 302), to be a Homalothecium, but is still given a place in this key.

ii. *Costa strong.*

* *Capsule oval or oblong, operculum convex-conic.*

Leaves entire . . . . . **H. atrovirens, 1.**
Leaves serrulate at apex . . . . . **H. radicosum, 3.**

* * *Capsule cylindric, or if oval-oblong then operculum long-rostrate* (excl. *H. gracile.*)

+ *Plants small (to 5 cm.) delicate, creeping, 1—2-pinnate.*

++ *Costa of stem-leaves wide ($\frac{1}{6}$ leaf-base.)*

Stems papillose . . . . . **H. pygmæum, 7.**
Stems radiculose-tomentose . . . . . **H. minutulum, 6.**

++ ++ *Costa of stem-leaves half as wide.*

Stem-leaves with long pellucid point, cilia 0 . . . . **H. erectum, 9.**
Stem-leaves short acuminate, cilia 2 . . . . . **H. scitum, 8.**
Stem-leaves long acuminate, cilia 3 . . . . . **H. gracile, 10.**
Stem-leaves long acuminate, cilia 1 . . . . **H. calyptratum, 11.**

+ + *Plants large (to 10 cm.), creeping, 2—3-pinnate, forming extensive flat mats.*

Perichætial leaves long ciliate below.
Apical cells of branch-leaves not papillose, ovate, projecting . . . . . **H. tamariscinum, 12.**
Apical cells of branch-leaves oblong, with 2—3 papillæ **H. delicatulum, 14.**
Perichætial leaves not ciliate, apical cells of branch leaves round . . . . . **H. recognitum, 13.**

+ + + *Plants large (to 10 cm.), erect, 1-pinnate, in wide tufts.*

Capsule narrowly cylindric (1:5—6) . . . . . **H. abietinum, 15.**
Capsule oblong-cylindric (1:3) . . . . . **H. Blandovii, 16.**

b. *Paraphyllia 0.*

Seta smooth.
Plants in large mats, leaves serrulate at apex, costate to middle . . . . . **H. Brewerianum, 66**
Plants minute, leaves serrulate all round, costate to apex . . . . . **H. leuconeurum, 19.**
Seta rough.
Stem leaves with hyaline piliferous point . . **H. ramulosum, 21.**
Stem leaves not hyaline pointed.
Perichætial leaves costate . . . . . **H. Whippleanum, 20.**
Perichætial leaves ecostate.
Bright green, leaves open, loosely imbricate . **H. laxifolium, 23.**
Dirty or yellowish green, leaves sub-falcate secund, closely imbricate . . . . . **H. crispifolium, 22.**

2. *Leaves not papillose.*

a. *Shortly bicostate.*

Stem-leaves filiform-pointed . . . . . **H. procurrens, 5.**
Stem-leaves not filiform-pointed.
Obscurely denticulate at apex . . . **H. leucocladulum, 25.**
Distinctly denticulate all around . . . **H. compressulum, 26.**

b. *Unicostate or ecostate.*

i. *Paraphyllia numerous, ciliate* . . . . . **H. paludosum, 24.**

ii. *Paraphyllia 0.*

* *Leaves coarsely serrate, plants dendroid.*

Branch leaves apparently 2-ranked, complanate . **H. Bigelovii, 97.**
Branch leaves equally spreading.
Perichætial leaves reflexed, dioicous.
Cilia of endostome equalling teeth . . . . . **H. Leibergii**[1].
Cilia short . . . . . **H. neckeroides, 96.**
Perichætial leaves erect, heteroicous . . **H. Alleghaniense, 95.**

* * *Leaves entire, plants creeping.*

+ *Ecostate or with obscure traces of a nerve.*

Cilia 0.
Capsule constricted under mouth when dry . . **H. subtile, 117.**
Capsule not constricted . . . . . **H. Sprucei, 116.**
Cilia 1—2.
Plants minute, filiform.
Leaves ovate, long acuminate . . . . **H. confervoides, 118.**
Leaves long-lanceolate . . . . . **H. minutissimum, 115.**
Plants large, in wide flat mats . . . . . **H. adnatum, 124.**

+ + *Costate.*

++ *Leaves bordered with 4—5 rows of linear cells* **H. Lescurii, 126.**

++ ++ *Leaves not bordered.*

= *Plants in compact tufts 2—3 cm. deep* . . **H. compactum, 125.**

= = *Plants in loose mats or tufts.*

¶ *Costate to apex.*

Leaves acuminate.
Basal cells much enlarged . . . . . **H. irriguum, 122.**

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[1] Britton: *Bull. Torr. Bot. Club*, xvi (1889), 111.

Basal cells not enlarged.
Annulus triple . . . . . **H. radicale, 120.**
Annulus simple . . . . . **H. orthocladon, 121.**
Leaves not acuminate . . . . . **H. fluviatile, 123.**

Costa ceasing above the middle.

Cells alike throughout.
Inner perichætial leaves with a short (¼ length) point.
Capsule long cylindric, arcuate, annulus triple . **H. serpens, 119.**
Capsule oblong, oblique, annulus simple . **H. Kochii** Br. & Sch.[1]
Inner perichætial leaves subuliform-acuminate, cells vermicular . . . . . **H. porphyrrhizum** Lindb.[1]
Cells enlarged, rectangular at basal angles.
Cilia appendiculate, equalling segments . . **H. riparium, 127.**
Cilia rugulose, shorter than segments . . . **H. vacillans, 128.**

B. *Leaf cells elongated* (1:5 *or more*).

[**Amblystegium** spp. especially 127, 128 may be sought here.]

1. *Leaves costate half way or more.*

a. *Seta rough.*

i. *Leaves deeply plicate lengthwise.*

[**Brachythecium** spp. may be sought here.]

Plants regularly pinnate.
Seta scarcely equalling capsule . . . . . **H. Nuttallii, 29.**
Seta longer than capsule.
Perichætial leaves coarsely sinuate-dentate, cilia 0 **H. Nevadense,**[2] **30.**
Perichætial leaves entire or serrulate.
Stems erect, stout (to 15 cm.) . . . . . **H. megaptilum, 34.**
Stems prostrate.
Leaves with recurved, spinulose teeth . **H. hamatidens,**[3].
Leaves serrulate.
Capsule oblong . . . . . **H. pinnatifidum, 31.**
Capsule long cylindric . . . . . **H. Amesiæ,**[4].
Plants irregularly branched.
Leaves ovate-lanceolate (1:3) cilia 3, long as segments **H. æneum, 28.**
Leaves long-lanceolate (1:5) cilia 1 or 2, long or short **H. lutescens, 27.**

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[1] Renauld & Cardot: *Bot. Gaz.*, xiv (1889), 99.
[2] *Homalothecium Nevadense* Ren. & Card.: *Bot. Gaz.*, xiii (1888), 202.
[3] Kindberg: *Bull. Torr. Bot. Club*, xvi (1889), 97.
[4] Renauld and Cardot: *Bot. Gaz.*, xiii (1888), 202, pl. XX.

II. *Leaves not deeply plicate.*

[**Homalothecium pseudo-sericeum** may be sought here.]

* *Lid convex-conic to long-conic (rostellate in 59).*

+ *Leaf-cells not abruptly enlarged at base, upper usually dist elongated rhombic.*

++ *Seta smooth above, rough below, capsule subcrect.*

Capsule 1:1.5, cilia 2, equalling teeth . . . . **H. Hillebrandi**
Capsule 1:2.5, cilia solitary, short, or none . . **H. Fendleri**

+++ *Seta smooth below, rough above, capsule cernuous or arcua*

Perichætial leaves short-acuminate . . . . **H. plumosum**
Perichætial leaves abruptly long filiform-acuminate **H. campestre**

++++ *Seta rough throughout.*

= *Cells of basal angles scarcely different.*

Leaves scarcely or abruptly acuminate, dioicous.
Leaves very short acuminate, glossy, not decurrent **H. rivulare**
Leaves short acuminate, broadly and long decurrent. **H. latifolium, Lin**
Leaves longer acuminate, not glossy, decurrent . **H. Novæ-Angliæ**
Leaves gradually acuminate, autoicous.
Slender, leaves lanceolate to ovate-lanceolate, capsule constricted under mouth when dry . . **H. velutinum**
Stout, leaves ovate, capsule not constricted . **H. rutabulum**

== *Cells of basal angles distinctly quadratic.*

Leaves long acuminate, costa entering point . . **H. reflexum**
Leaves acuminate, costa not reaching point.
Seta long (4 cm. +) . . . . . **H. asperrimum**
Seta shorter (2 cm. −).
Segments split between articulations . . **H. œdipodium**
Segments split their whole length[2]
Seta arcuate above . . . . . **H. Bolanderi**
Seta abruptly bent at base of capsule . . **H. Starki**

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[1] Renauld and Cardot: *Fl. Mic.* (1888) 51.

[2] According to Austin *Bot. Gaz.*, iv (1879), 162, the pedicel of *H. lacerosum* obsoletely scabrous, and it might therefore be sought here.

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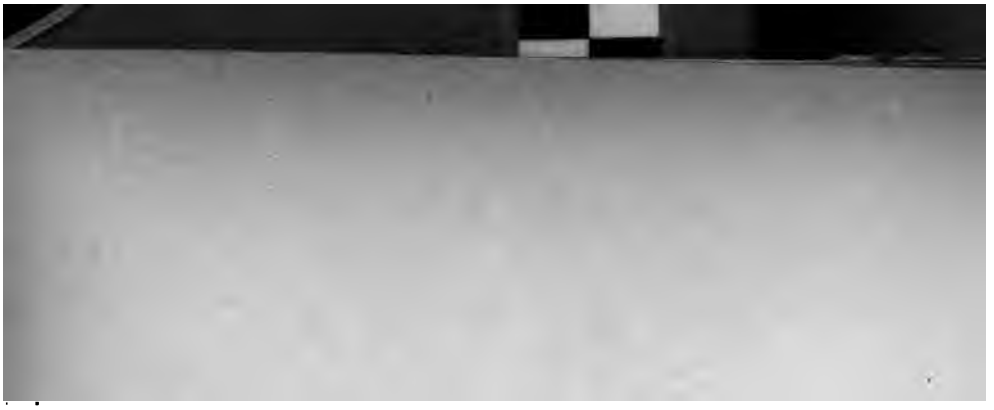

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+— +— Leaf-cells abruptly enlarged at base, indistinct, linear-vermicular.

Costa percurrent . . . . . **H. populeum, 57.**
Costa vanishing.
Seta purplish, rough throughout.
Capsule suberect, stem-leaves gradually acuminate **H. cæspitosum, 59.**
Capsule abruptly horizontal, leaves abruptly short acuminate with points recurved . . **H. illecebrum, 61.**
Seta reddish and rough above, yellowish and smooth below . . . . . **H. Californicum, 60.**

** * Lid (more or less long) rostrate.*

+— Leaves obtuse . . . . . **H. obtusifolium, 169.**

+— +— Leaves acute or acuminate.

++ Cilia solitary or geminate at base.

Perichætial leaves erect, serrulate . . . . . **H. curvisetum, 91.**
Perichætial leaves recurved, entire . . . . . **H. lentum, 69.**

++ ++ Cilia 2—3.

Leaves with filiform points.
Stems short, with erect fasciculate branches, stoloniferous . . . . . **H. Vaucheri, 73 a.**
Stems long, prostrate, irregularly branched, not radiculose . . . . . **H. piliferum, 74.**
Leaf-points not filiform.
Leaves serrulate all around.
Decurrent, excavate at basal angles.
Perichætial leaves spreading . . . . . **H. Stokesii, 78.**
Perichætial leaves reflexed . . . . . **H. Oreganum, 79.**
Not decurrent nor excavate.
Leaves ovate-lanceolate, acuminate, segments split . . . . . **H. Sullivantii, 76.**
Leaves broad-ovate, acute, segments perforate **H. prælongum, 75.**
Leaves entire at base.
Lid not half as long as capsule . . . **H. colpophyllum, 73.**
Lid nearly as long as capsule . . . . . **H. hians, 77**

b. *Seta smooth.*

[**Homalothecium pseudo-sericeum** may be sought here.]

i. *Lid (more or less long) rostrate.*

Leaves apparently 2-ranked; plants of dry woods . **H. serrulatum, 89.**

Leaves spreading every way.
  Ovate, acute, rarely slender-pointed; in water . **H. ruseiforme, 90.**
  Deltoid, with long slender points.
    Points twisted, plants golden yellow . . . **H. Boscii, 72.**
    Points straight.
      Spreading, branchlets attenuate . . . **H. strigosum, 70.**
      Appressed, branchlets short, julaceous . **H. diversifolium, 71.**

ii. *Lid convex to conic.*

* *Leaves acute or acuminate, serrulate.*

+ *Primary branches erect, dendroid to fasciculate, capsule symmetric, subcrect or inclined.*

++ *Leaves papillose on back.*

In compact tufts, dark green, branchlets not attenuate
H. Brewerianum, 66.
In loose tufts, branchlets attenuate, stoloniferous.
  Cilia solitary, margin of stem leaves reflexed . **H. spiculiferum, 64.**
  Cilia 2—3, margin of stem leaves not reflexed . **H. stoloniferum, 63.**

++ ++ *Leaves smooth.*

Capsule cylindrical, cilia solitary, ½ segments . **H. aggregatum, 67.**
Capsule oval-oblong, cilia 2—3.
  Perichaetial leaves serrate . . . . . **H. myosuroides, 62.**
  Perichaetial leaves entire . . . . . **H. acuticuspis, 65.**

+ + *Primary branching irregular or pinnate, capsule unsymmetric, subarcuate, horizontal* (excl. 36 and 44).

Capsule symmetric, erect.
  Synoicous, small (branches 1 cm. long) . . . **H. Utahense, 44.**
  Dioicous, large (branches 3—4 cm.) . . . **H. acuminatum, 36.**
Capsule unsymmetric, inclined.
  In loose tufts, plants stout or long.
    Leaves narrowed from lower third to apex, usually whitish or yellowish.
      Capsule short (1:1.5), monoicous, leaves straight when dry . . . . . **H. salebrosum, 37.**
      Capsule short (1:1.5—2), dioicous, leaves twisted-flexuous when dry . . . . . **H. Thedenii, 41.**
      Capsule longer (1:3), dioicous, leaves straight when dry . . . . . **H. lætum, 35.**
    Leaves narrowed from base to apex, bright green, monoicous . . . . . **H. acutum, 38.**

In loose tufts, plants small, bright green, dioicous **H. biventrosum**, 40[1].
In dense hemispherical bright green tufts, monoicous **H. collinum**, 43.

* * *Leaves acute or acuminate, entire.*

+ *Capsule strongly constricted under mouth when dry.*

Leaves widest just at base, tapering equally.
Deeply plicate, cells obscure . . . . . **H. nitens**, 33.
Concave, smooth, cells plain . . . . . **H. polygamum**, 132.
Leaves widest above base, long-acuminate . **H. chrysophyllum**, 130.
Leaves widest above base, not acuminate . . . **H. palustre**, 165.

+ + *Capsule slightly or not constricted.*

Plants reddish-brown below, orange above . . . **H. badium**, 183.
Plants whitish-,yellowish- or bright green.
Cilia 0, basal cells quadrate, numerous . . . **H. Donnellii**, 42.
Cilia 2.
Monoicous, leaves open . . . . . **H. salebrosum**, 37.
Dioicous, leaves appressed-imbricate . . . **H. albicans**, 39.
Cilia solitary.
Alar cells loosely quadrate, thin . . . **H. oxycladon**, 53a.
Alar cells round-quadrate, obscure. . . . **H. apocladum**, 68.

* * * *Leaves obtuse (sometimes apiculate in 175) entire.*

+ *Cells not enlarged at basal angles.*

Leaves open . . . . . **H. arcticum**, 168.
Leaves closely imbricate . . . . . **H. trifarium**, 181.

+ + *Cells enlarged at basal angles.*

Costa subpercurrent.
Monoicous, sparingly branched, alar cells gradually enlarged . . . . . **H. cordifolium**, 173.
Dioicous, profusely branched.
5—10 cm. long, variegated or dark purple, stolons green . . . . . **H. sarmentosum**, 175.
15—30 cm. long, bright- to yellowish green . **H. giganteum**, 174.
Costa reaching middle.
Branches irregularly pinnate, leaves spreading . **H. Richardsoni**, 177.
Branches few, leaves imbricate . . . . **H. stramineum**, 180.

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[1] The sterile *H.* (Brachythecium) *Fitzgeraldi*, Müller (*Flora*, 1887, 224), is related to this species and distinguished from it "by its parallel julaceous-terete branches and larger, broader and less acuminate leaves."

2. *Costa very short or none or double.*

a. *Alar cells abruptly enlarged (often inflated and colored).*[1]

i. *Operculum long subulate rostrate.*

Capsule horizontal, strongly constricted under mouth when dry, leaves quite entire . . . . . **H. demissum, 80.**
Capsule suberect, slightly constricted, leaves serrulate at apex . . . . . **H. microcarpum, 84.**
Capsule inclined, wide mouthed, leaves spinulose-dentate at apex . . . . . **H. laxepatulum, 86.**

ii. *Operculum short rostrate.*

Leaves roundish elliptical, subacute or apiculate . **H. Novæ-Cæsariæ, 81.**
Leaves filiform acuminate.
Cilia 2, annulus 0, capsule oblong (1:2—2.5) . . **H. recurvans, 82.**
Cilia 0, annulus 0, capsule cylindric (1:3.5) . **H. cylindricarpum, 83.**
Cilia 1, annulus simple, large, capsule oblong . . **H. Jamesii, 85.**
Leaves acute or stoutly acuminate.
Entire . . . . . **H. Haldanianum, 163.**
Sharply serrate . . . . . **H. nemorosum, 164.**

iii. *Operculum convex or conic.*

Leaves falcate.

(**H. palustre**, var. **hamulosum** may be sought here.)

Scarcely costate, alar cells orange . . . . . **H. eugyrium, 171.**
Costa reaching middle, alar cells hyaline . . **H. ochraceum, 172.**
Leaves not falcate.
Abruptly filiform apiculate, entire, alar cells not conspicuous . . . . . **H. trichophorum, 100.**
Gradually filiform acuminate, alar cells orange.
Acute or short apiculate, alar cells few, large . **H. palustre, 165.**
Plants slender, 2—3 cm. long.
Branches erect, leaves serrate . . **H. Muhlenbeckii, 111.**
Branches intricate, leaves nearly entire . **H. Fitzgeraldi, 112.**
Plants stout, 7—10 cm. long, leaves quite entire **H. stellatum, 131.**
Obtuse, entire, alar cells hyaline . . . **H. cuspidatum, 176.**

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[1] In 81 so few as to be easily overlooked.

b. *Alar cells scarcely different or quadrate, not abruptly enlarged.*

1. *Leaves thin, glossy, open; plants mostly small, prostrate or with ascending branches.*

* *Leaves complanate.*

+ *Lid rostrate.*

Leaves transversely undulate, serrulate at apex . **H. undulatum, 110.**
Leaves not undulate, quite entire . . . . . **H. sylvaticum, 109.**
Leaves not undulate, serrulate to base.
Bicostate, annulus large . . . . . **H. geophilum, 87.**
Uni- or ecostate, annulus 0 . . . . . **H. deplanatum, 88.**

+ + *Lid convex or conic.*

Capsule pendent . . . . . **H. elegans, 105.**
Capsule suberect, inclined or horizontal.
Sulcate and constricted below mouth when dry . **H. turfaceum, 104.**
Smooth when dry.
Autoicous, plants growing on rotten wood.
Annulus 0 . . . . . **H. micans, 103.**
Annulus large, triple . . . . . **H. denticulatum, 106.**
Dioicous, plants growing on stones or the ground.
Leaves quite entire, capsule obovate, campanulate when dry . . . . . **H Muellerianum, 107.**
Leaves serrulate, capsule subcylindric . **H. Sullivantiæ, 108.**

* * *Leaves equally spreading.*

+ *Capsule suberect, smooth when dry.*

Dioicous, cilia 0, costa obsolete.
Inner perichætial leaves ovate lanceolate . . **H. latebricola, 98.**
Inner perichætial abruptly acuminate . . **H. Passaicense, 99.**
Autoicous, cilia 2—3, costa double.
Thick, ascending to middle . . . . . **H. geminum, 102.**
Thin, reaching half way to middle . **H. denticulatum, var. 106.**

+ + *Capsule inclined, sulcate when dry* . **H. pseudo-Silesiacum, 113.**

+ + + *Capsule inclined or horizontal, often arcuate, smooth when dry.*

Leaves squarrose, abruptly long acuminate . **H. hispidulum, 129.**
Leaves loosely imbricate, obtuse or acute, alar cells orange.
Nearly as broad as long, obtuse or apiculate . . **H. molle, 166.**
Nearly twice as long as broad, acute, point often half twisted . . . . . **H. alpestre, 167.**
Leaves falcate, gradually acute . . . . . **H. montanum, 170.**

II. *Leaves firm, plants very large, mostly 1—2-pinnate, erect or ascending.*

* *Paraphyllia 0.*

Leaves obtuse or abruptly apiculate.
  Capsule smooth when dry.
    Leaves obtuse.
      Olive or grayish green, 1—2-pinnate, leaves open **H. Schreberi**, 178.
      Dirty green to dark brown, almost simple, leaves closely appressed . . . . . **H. trifarium**, 181.
    Leaves abruptly apiculate, plants pale green . **H. purum**, L.[1].
  Capsule plicate when dry, plants dark green to reddish brown . . . . . **H. scorpioides**, 184.
  Capsule unknown; plants dark yellow and greenish, branches julaceous, few, fastigiate, leaves short apiculate **H. turgescens**, 182.
Leaves long acuminate.
  Sulcate.
    Apex blunt . . . . . **H. Flemmingii**, 191.
    Apex very sharp.
      Ecostate, leaf cells all alike . . . . . **H. loreum**, 192.
      Bicostate, leaf cells enlarged at base . . **H. triquetrum**, 190.
  Not sulcate . . . . . **H. squarrosum**, 189.

* * *Paraphyllia present.*

Leaves with long double costa, leaves deeply sulcate **H. umbratum**, 186.
Leaves obscurely bicostate.
  Obtuse . . . . . **H. Alaskanum**, 179.
  Acute or apiculate or long acuminate.
    Paraphyllia pinnate, branches densely 2—3 pinnate **H. splendens**, 185.
    Paraphyllia minute, branching irregularly pinnate **H. brevirostre**, 188.
Leaves unicostate to middle, coarsely serrate . . **H. Oakesii**, 187.

II. *Leaves secund.*

[**Raphidostegium** spp. and **Brachythecium Thedenii** may be sought here.]

A. *Costa single, reaching to the middle or beyond.*

1. *Cells short, minute* . . . . . **H. crispifolium**, 22.

2. *Cells elongated.*

a. *Seta rough.*

Leaves serrulate . . . . . **H. velutinum**, 45.
Leaves entire . . . . . **H. plumosum**, var. 58.

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[1] Renauld and Cardot: *Fl. Mig.* 57.

b. *Seta smooth.*

i. *Leaves transversely rugose and longitudinally plicate.*

Plants slender . . . . . **H. adunc**um var. **gracilescens**, 133.
Plants very stout.
Leaves serrate at apex, alar cells quadrate . . **H. rugosum**, 144.
Leaves subserrate at apex, alar cells scarcely different, **H. robustum**, 145.

ii. *Leaves not rugose, often plicate.*

* *Alar cells much enlarged or differently colored.*

+ *Paraphyllia abundant (rarely few).*

Leaves plicate . . . . . **H. commutatum**, 143.
Leaves not plicate . . . . . **H. filicinum**, 142.

+ + *Paraphyllia 0.*

Annulus 0.
Autoicous, leaves quite entire . . . . . **H. palustre**, 165.
Autoicous, leaves denticulate . . . . . **H. fluitans**, 136.
Dioicous, leaves entire above, serrulate below **H. exannulatum**, 137.
Annulus large.
Autoicous, leaves plicate, teeth orange at base, yellowish above . . . . . **H. uncinatum**,[1] 135.
Dioicous, leaves sulcate, teeth orange with a broad hyaline border . . . . . **H. ochraceum**, 172.
Dioicous, leaves striate, teeth brown or dark orange, not bordered.
Alar cells pellucid . . . . . **H. adunc**um, 183.
Alar cells orange . . . . . **H. Sendtneri**, 134.

* * *Alar cells small or scarcely different.*

Leaves serrate . . . . . **H. Thedenii**, 41.
Leaves quite entire.
Plants very large and stout (15—20 cm.), leaves costate to near apex.
Regularly pinnate . . . **H. adunc**um var. **hamatum**, 133.
Irregularly and dichotomously branched . **H. lycopodioides**, 140.
Plants much smaller, leaves obscurely bicostate . **H. Watsoni**, 141.
Plants much smaller, leaves costate to above middle.
Autoicous, purplish-red, red-brown or nearly black **H. revolvens**, 138.
Dioicous, dirty green or yellow . . . **H. vernicosum**, 139.

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[1] *Hyp. symmetricum* Ren. et Card. (*Bot. Gaz.* xiv (1889), 99, pl. xv), is a sub-species of H. uncinatum, from which it is distinguished by the "narrower, erect and quite symmetric capsules, sometimes clustered by two in same perichætium."

B. *Costa double, short, or none.*

1. *Alar cells enlarged, hyaline or colored.*

a. *Lid conic, often apiculate, capsule oval to oblong* (1:1—2.5).

i. *Alar cells pellucid, not conspicuously colored.*

* *Capsule costate and arcuate when dry.*

Alar cells short, yellow, thick walled . . . **H. curvifolium, 159.**
Alar cells inflated, hyaline, thin-walled . . **H. arcuatum,**[1] Lindb.

* * *Capsule not costate when dry.*

Vaginule short (1: 2) covered with longer hairs . **H. molluscum, 147.**
Vaginule longer (1:3+)
Plants shining yellow, leaves subserrulate . **H. depressulum, 151.**
Plants bright- to pale green, leaves quite entire.
Lid sharply apiculate, orange, capsule incurved when dry . . . . . **H. callichroum, 154**
Lid not apiculate, capsule strongly arcuate when dry **H. pratense, 161.**

ii. *Alar cells orange.*

Leaves quite entire . . . . . **H. Bambergeri, 162.**
Leaves serrulate.
Ecostate . . . . . **H. circinale, 152.**
Obsoletely bicostate . . . . . **H. Sequoieti, 153.**

b. *Lid rostrate, capsule cylindric* (1: 3.5 +).

Leaves laterally compressed both sides, alar cells orange **H. Bambergeri, 162.**
Leaves not laterally compressed.
Perichætial leaves bicostate to middle, plicate . . **H. reptile, 148.**
Perichætial leaves shortly bicostate, plicate . **H. cupressiforme, 158.**
Perichætial leaves ecostate, plicate, cilia solitary, appendiculate . . . . . **H. imponens, 155.**
Perichætial leaves ecostate, not plicate, cilia 2, inappendiculate . . . . . **H. subimponens, 156.**

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[1] Renauld and Cardot: *Fl. Miq.* 55.

2. *Alar cells not distinct, often quadrate.*

a. *Plants very stout (5—6 mm. thick), leaves transversely rugose* . . . . . **H. robustum, 145.**

b. *Plants much more slender (2 mm. or less thick), leaves not rugose.*

Costæ 2, thick, reaching the middle . . . . **H. geminum, 102.**
Ecostate or shortly bicostate.
Irregularly branched.
Leaf margins reflexed, shortly bicostate . . **H. plicatile, 157.**
Leaf margins plane, shortly bicostate . . **H. Vaucheri, Lesq.**[1]
Leaf margins plane, ecostate . . . . **H. pulchellum, 101.**
Regularly pinnate.
Plants very large (to 15 cm.), capsule arcuate, stem leaves plicate . . . . . **H. Crista-castrensis, 146.**
Plants smaller (usually less than 5 cm.), capsule not arcuate nor stem leaves plicate.
Perichætial leaves plicate.
Leaves quite entire . . . . . **H. complexum, 160.**
Leaves serrulate at apex.
Inner perichætial leaves costate . . . **H. fertile, 149.**
Inner perichætial leaves ecostate . . **H. hamulosum, 150.**
Perichætial leaves not plicate . . . **H. subimponens, 156.**

[1] Renauld & Cardot: *Bot. Gaz.* xiv. (1889) 100.

SOME ADDITIONAL EVIDENCES BEARING ON THE INTERVAL BETWEEN THE GLACIAL EPOCHS.

BY PRESIDENT T. C. CHAMBERLIN.*

Evidences bearing upon the interval between the glacial epochs may be drawn from various parts of the glaciated field and from the various phenomena connected with glaciation. It is not, however, my purpose to make any approach to an exhaustive review of these evidences, or even to touch upon the arguments that may be drawn from all the several sources. I desire simply to bring to your attention certain specific evidences that have an important bearing upon the length of the main interglacial interval and that lend themselves more readily to intellectual estimation than others. The evidences that are especially additional to previous knowledge are drawn from the lower Mississippi Valley, but, in connection with these, I shall briefly refer to evidences drawn from other valleys that fall into marked harmony with these.

In the lower Mississippi Valley, the sub-stratum consists of Tertiary deposits. Upon these there is a thin stratum of gravel and sand, known heretofore quite widely as the Orange Sands, although that term seems to have been applied to different formations. This stratum has been very considerably misunderstood. It does not contain, so far as critical investigation shows, any material that may be regarded as glacial, although I think in some of the earlier reports Archean pebbles were cited as an indication that these gravels were contemporaneous with the glacial deposits of the north. They have been critically examined during the summer by my colleague, Professor Salisbury, and during the entire season's search he has not found a single pebble that is referable to a glacial origin. Some years since I examined the same formation with like result. Professor Call has also examined some of these deposits with a similar result. The pebbles are chiefly of chert and were derived from the chert-bearing limestones, largely Carboniferous, but reaching as far down as the Lower Magnesian limestone. They are, therefore, non-glacial. This is a matter of some importance as these sands and gravels have been correlated with the glacial deposits not only but referred to the Champlain epoch. They are very far removed from the Champlain deposits in time. That correlation is one of the great errors of Quaternary geology. They are certainly pre-

* The facts relative to the Lower Mississippi region are drawn largely from the observations of my associate, Prof. R. D. Salisbury.

glacial in the sense that they were not contemporaneous with the glacial incursion at its earliest maximum. They may have been contemporaneous with the very earliest stages of glaciation before the ice reached the Mississippi Valley and was able to mingle its deposits with those of valley.

Now these gravels occupy a wide area stretching across the basin of the lower Mississippi from some distance back in Tennessee, Kentucky and Mississippi to the high lands upon the Arkansas side, appearing in Crowley's ridge that bisects the present bottoms of the Mississippi. The gravel stratum undoubtedly was originally horizontal, but it now undulates more or less conformably with the surface. The explanation of this, it seems to me, is found in the gradual creep of the soft material of the hills as they were slowly carved out by erosion. The brows of the hills in some cases have obviously crept down on the slopes, for on the summit we find the gravels compact and firm and the constituent pebbles lying with their maximum diameters in a horizontal position while the stratum has level upper and lower bounding planes. On the slopes of the hills however the gravel beds are more or less broken up, and the pebbles have been disturbed and displaced and tumbled into various attitudes, such as we might naturally expect under the hypotheses of a creeping movement on the slope. It seems impossible to suppose that this stratum of gravel was originally deposited in the undulatory form in which it is now found. It might be supposed that the silt which overlies this gravel bed was deposited as a mantle over an undulatory surface, but gravel does not lend itself to such a method of distribution.

This overlying mantle, which now claims attention, consists of fine silt and embraces the loess deposits of the lower Mississippi. It spreads out broadly over the gravel stratum and extends somewhat beyond it, especially on the east. This stratum is in places differentiated into two parts and separated by a soil-like horizon. This differentiation is not common to the entire valley. This silt mantle may be traced almost in unbroken continuity northward to the border of the glacial drift, whence it spreads itself over the drift, reaching up on it some hundreds of miles to the northward. In this northern stretch the silt mantle is correlated with a second episode of the earlier glacial epoch. It graduates down into a stratum of boulder clay that overlies a bed of vegetable material, which in turn overlies another till. Both of these tills I have been accustomed to correlate with the earlier glacial epoch. I do not wish, however, to raise differences of opinion on that point here. It is unimportant to the main conclusions which we desire to reach.

Besides this continuity there is a further reason for regarding these silt deposits as contemporaneous with the ice invasions. They are made up in part of glacial particles; that is, particles derived from the mechanical abrasion of a glacier. These particles consist of decomposable silicates, dolomites and limestones, and were rasped from rocks of these varieties lying further north. Such decomposable particles do not abound in residuary clays but are abundant constituents of glacial clays.

It seems necessary to suppose that this mantle of loess and loess-like silt was originally deposited as a horizontal stratum across the entire Mississippi bottoms. At the present time it undulates over the hills. At first thought it would seem that the depositing waters might have been deep and the silt laid down as an undulatory mantle; but it would seem necessary to extend the same hypothesis to the deposition of the gravels where its application is manifestly excluded by the nature of the deposit. I feel sure from observation in certain cases that full investigation will show that this seeming mantling is the result of the gradual degradation of the hills, accompanied by creep of the pliant and plastic material. This phenomenon of creep has a wide expression entirely independent of the area under consideration; but upon that I cannot dwell.

During the first glacial episode the altitude and slope of the lower Mississippi basin was so low as to permit the deposit of this silt on the bluffs which are now 200 feet more or less above the present Mississippi bottoms. Before the second glacial epoch, according to the division I make, there was an elevation sufficient to permit the erosion of the great trench of the lower Mississippi by the predecessor of the present river. This erosion amounts in round numbers to a trench about 300 feet in depth and about sixty miles in width. Some of the bluffs that are crowned by these silts are 200 or 250 feet in height, and Professor Call's recent investigations show 80 to 100 feet of silt in the bottom. It is, therefore, I think, safe to say that in round numbers there was an erosion during the interval between the two epochs of the magnitude named and reaching from Cairo south to the gulf with corresponding erosion trenches along the upper branches. This great erosion represents the interval between the formation of the silts of the earlier glacial epoch and the filling in of the valley deposits of the later glacial epoch, which now demand our attention. If we go back on the glaciated area to the moraines which mark the limit of the later glacial incursions, we shall find, starting from the outer side of these moraines, valley streams of gravel formed contemporaneously with these ice incursions. Tracing these gravel streams along their courses, we find that they run down into the channels cut in the inter-glacial interval, and partially fill them. On the upper Mississippi, on the Chippewa, on the Wisconsin and on other tributary rivers, we find gravel trains heading on the outer edge of the outer moraine of the later epoch. Passing down through the interglacial trenches, these are found represented in the lower Mississippi valley, as I think we may safely say from recently gathered evidence, as deposits in the Mississippi bottoms, overlaid of course by the more recent deposits. The work of the earlier glacial epoch in the lower Mississippi I conceive to be the deposit of the loess and loess-like silt, that of the interglacial epoch to be the erosion of the great trench in which the Mississippi bottoms now lie, and that of the later glacial epoch to be the partially filling of this trench. The trenching is the measure of the interglacial interval, or at least is a partial measure of it.

If we pass to the upper Ohio and Allegheny valleys we find phenomena that fall into close correspondence with the foregoing. There are high shoulders and terraces at various points which bear upon themselves glacial river gravels. One of the most decisive is found in the vicinity of Parkers, and has been described by Mr. Chance and others. Here an old channel runs back from the present course, and curving around a group of hills, returns, forming an "ox bow." In this old channel glacial river gravels are found, showing that it was occupied contemporaneously with some stage of the glacial period. This abandoned channel is about 200 feet above the present Alleghany river. Mr. Chance tells us there is about fifty feet of drift in the present valley bottom. So between this upper river bed and the bottom of the present rock channel there is evidence of an erosion of 250 feet, 200 of which, in round numbers, are cut through Carboniferous strata. Similar and corroborative facts show themselves along the course of the river above and below and along the Monongohela and the upper Ohio. If we trace the old channel of the Alleghany northward by means of remnant shoulders and terraces we find that it lies considerably above the altitude of the terminal moraines of the later epoch; and also much above the gravel trains that head on the outer side of these moraines and run down through the trench above indicated. It therefore becomes a necessary inference that the trench was cut before the moraines were pushed across it and before the moraine derived gravels could be carried down into it. The trench therefore represents the interval between the earlier and the later glacial epochs. I have placed in manuscript elsewhere the fuller facts upon which these brief statements rest, and they will appear in print in time.

If we pass over the Susquehanna valley we find like phenomena. These have been brought out by Mr. McGee and others and I need only to refer to them because of their connection with that which I have already presented. Here we find old benches covered with rounded pebbles — some of which are glaciated — reaching to a similar height of about 250 feet above the present Susquehanna river. There are glaciated pebbles at higher altitudes, but I have taken the more moderate figure because it is a safe one. Near Sunburg glaciated stones were found by Professor Salisbury about six hundred feet above the present river. Below these high terraces and in the valley excavated out of the plain from which they were derived, we find a lower terrace 60 or 70 feet in height of newer and distinguished aspect. Above Berwick this lower terrace connects itself definitely with the terminal moraine which there crosses the river. The terrace rises rapidly as it joins this moraine, as is the habit of moraine-headed terraces, and reaches an altitude of 100 to 150 feet as it merges into the moraine. But it is still much below the old terraces from which it is sharply distinguished by its freshness and youth and by its constituent material.

It appears therefore that at this point a deep trench was cut in the flood-plain of which the old terraces are the remnants before the formation of the later moraine and of the valley deposits that sprang from it.

If we pass over to the Delaware valley we find analagous facts which are more familiar through the writings of several geologists. Many years ago Professor Lewis called attention to the earlier and later deposits of that region, though he did not give them the interpretation I shall place upon them here, which coincides essentially with that of McGee. As we follow up the valley toward Belvidere where the moraine crosses the Delaware, we find old terraces reaching up to about 240 or 250 feet upon which are rounded pebbles and glaciated stones, indicating an origin in the earlier stage of glaciation. Cutting through these old plains and the rock below we find the deep trench in which the later deposits have been placed. These later gravel deposits, originating with the moraine at a height of somewhat above 150 feet, rapidly decline to about 85 feet a few miles above Lewisburg, opposite a point where the older terrace rises to about 250 feet. The measure of the interval here is some 250 to 300 feet of rock cutting.

It would appear therefore that while there are local variations, there is a general correspondence between the amount of erosive work done by the lower Mississippi, by the upper Ohio and Alleghaney, by the Susquehanna and by the Delaware rivers respectively. The facts indicate that the altitude of the continent was low in the closing stages of the earlier glacial epoch; became higher in the interglacial interval, and after sufficient time elapsed for these great erosions to take place, the glacial waters of the later epoch poured their valley deposits down the trenches formed in the interval. The cutting of these trenches rudely measures the length of this interval or at least the length of the actively erosive part of it.

ON THE APPENDAGES OF THE FIRST ABDOMINAL SEGMENT OF EMBRYO INSECTS.

BY WM. M. WHEELER.

Much of what is contained in the following paper was presented to the Wisconsin Academy of Sciences, Arts and Letters at its annual meeting in December, 1888. *Graber's* summary ['88], embodying as it does all that was known of the curious organs on the basal abdominal segment of embryo insects up to 1888, would seem to render superfluous a second general contribution at so early a date. Nevertheless I have been led to undertake the task for several reasons: First, several brief articles have appeared since the publication of *Graber's* comprehensive paper; secondly, I have myself made some observations which fill a few of the gaps necessarily left in the German investigator's resumé, and thirdly, as I take a very different standpoint in regard to the interpretation of the problematic appendages, I feel in duty bound to reproduce all the facts from which my conclusions are drawn.

This paper does not purport to be a final monograph on the subject — such a task can be undertaken only when the embryos of many more insects have been carefully studied — but a resumé of facts and theories up to the close of 1889. After giving an account of my own investigations in the first part, I shall in the second portion pass to an account of the work of other observers, and in the last part consider the theories which have been advanced in regard to the original function of the problematic organs. The descriptions of the organs in *Blatta* and *Periplaneta* and the whole of the theoretical portion are essentially the same as when presented to the Academy in December, 1888.

For the sake of avoiding repeated circumlocution I shall call the appendages of the first abdominal segment *pleuropodia* — a name both suggestive of their origin from foot-like organs and their tendency, when fully developed, to take up a position on the pleural wall of the embryo. Should the theory advanced in the latter part of the paper prove to be correct, I would suggest that the term *adenopodium* be substituted for *pleuropodium*.

I shall not treat of the abortive and very transient appendages which appear on some or all of the abdominal segments, since the interested reader will find a complete resumé of our fragmentary knowledge of these structures in *Graber's* paper ['88]. Nor do I propose to enter into the controversy as to whether the ancestral insects were homopod or heteropod,

because I believe, in contradiction to *Graber*, that there is nothing in the structure or evolution of the pleuropodia which throws any light whatever on the mooted question.

These organs may be turned to quite as good account by the advocates of homopody as by those who accept *Graber's* views. Supposing the Diptera were the only order of insects of which we had any knowledge, should we be justified in asserting that the halteres which now function as sense organs according to *Leuckart* and *Lee*, had never functioned as true wings? Certainly not. No entomologist doubts that the immediate ancestors of the Diptera were true insects and that they were provided with two pairs of perfect wings. It seems to me that the advocates of homopody may logically maintain that the pleuropodia present a strictly analogous case. These organs originate as appendages homologous with the thoracic legs though they subsequently differentiate into organs of problematic though certainly not ambulatory function. Why might not the pleuropodia have been true ambulatory appendages in ancestral forms no more remote from the living or even Palæozoic Orthoptera than some four-winged insects are from the Diptera?*

PART FIRST.

Blatta (Phyllodromia) germanica. L.

(Plate I, Figs. 1-9.)

The appendages of the embryo Blatta begin to appear on the tenth day from the formation of the polar globules. The antennae and the three pairs of thoracic limbs are the first to rise from the ectoderm of the hammer-shaped embryo. By the eleventh day the three pairs of oral and several

* A similar argument may be advanced in the case of the hamulate halteres of the male *Coccidæ*. Of deeper interest in this connection, however, are two facts recorded by Schioedte (De Metamorphosi Eleutheratorum Observationes, Kopenhagen, 1861-1883) concerning larval *Scarabæidæ* and *Lucanidæ*. In the larvæ of most species belonging to these families the metathoracic legs are as long as or a little longer than the meso- and prothoracic pairs. The larval *Geotrypes stercorarius*, L., however, has the hind legs reduced to only half the length of the anterior pairs. (Plate XVI, Fig. 1.) In the larval *Passalus cornutus*, Fabr. the hind legs are so far reduced as to be represented by a pair of small rudiments only. "Pedes tertii paris valde deminuti *Geotrypæ*, *Passalo*, completi *Geotrypæ*, femoribus, tibiis, unguli carentes *Passalo*." It is interesting to note that the rudiments in *Passalus*, as shown in Schioedtes' Figure (Plate XVIII, Fig. 12) are placed very near and somewhat pleurad to the bases of the median legs. The position thus assumed by the atrophied hind legs in respect of the median pair is exactly the same as that assumed in insect embryos by the pleuropodia in respect of the hind or metathoracic pair. The possibly unique, and certainly anomalous reduction of the hind legs in the larval *Geotrypes* and *Passalus* is well suited to show what striking changes may occur in the appendages within the limits of a single suborder of insects. This reduction, which is a purely larval character, since the imagines have hind legs of the usual size and structure, has very probably taken place within comparatively recent times.

pairs of rudimentary appendages on the abdominal segments have become visible. All the appendages are merely glove- finger-shaped outgrowths of the ectoderm into each of which extends a similar evagination of the underlying mesodermic somite. [Fig. 2.] Of the abdominal appendages all except the first pair soon disappear entirely. They are nipple-shaped elevations which are brought down to the general surface of the abdominal ectoderm by the tension resulting from the lateral and longitudinal growth of the embryo. The first pair of abdominal appendages in embryos twelve days old [Fig. 2 ap.], is twice as long as any of the succeeding evanescent appendages, and about half as long as the metathoracic legs.

Had I figured the whole of the sagittal section, of which Fig. 2 represents only a small portion, it would be seen that the three pairs of thoracic appendages are of equal length, and together with the antennae, the longest and most prominent appendages of the embryo. The abdominal pair is longer than the mandibles in this stage, but only about two-thirds as long as either the first or second maxillæ. Like the antennæ, oral and ambulatory appendages, they are directed obliquely outward and backward. The evanescent abdominal appendages, on the other hand, are directed forward.

The further differentiation of the antennæ, mandibles, maxillæ and feet is brought about by a very rapid proliferation of the constituent ectodermic cells, by a somewhat less rapid proliferation of the cells of the mesodermic somites of the appendages to form muscles, and by constrictions of the surface to form the joints of the adult insect. The differentiation of the first abdominal appendage is brought about in quite a different manner, namely, by the modification of the individual ectodermic cells of which its outer layer consists.

The appendage ceases to grow much in length after the twefth day and its cells no longer divide. I have never seen a nucleus in any phase of either karyokinesis or karyostenosis, notwithstanding I have examined many sections in all stages of development. Hence the number of cells which constitute the appendage on the twelfth day remains constant till the organ disappears. The cells which form all but its basal portion increase enormously in size, assuming the shape of long prisms more or less attenuated in some portion of their length. They grow inward and push the mesodermic cells which at first grew forward into the appendage, back into the body of the embryo. The cyptoplasm of these large cells consists of finely and evenly granular protoplasm in which there are one or two spherical or oval vacuoles at the peripheral ends. [Fig. 3, 4, *v.*] In surface views the cells are polygonal. The contour of the inner ends is indistinct in embryos fourteen days old.

Not only does the cytoplasm of each of the formerly small ectodermic cells increase thus enormously, but also the nuclei, which assume a centrifugal position in the fanshaped sections of the appendage. Owing to their number the nuclei are forced to arrange themselves in several rows.

[Fig. 3.] The karyochylema of these nuclei is colorless and shows no granulation. Through it are spread what under a low power appear to be distinct but isolated masses of chromatin.

Under a power of about 900 diameters the prismatic cells exhibit more of their true structure. The protoplasmic reticulum of the cytoplasm is indistinctly seen, most of its exceedingly delicate threads running parallel with the long diameter of the cells and presenting the appearance of fine striation. The parallel arrangement in this direction may be due to the tension of the protoplasm during the rapid centripetal growth of the cells. The nodes of the cytoplasmic reticulum are what appear as fine granules under a low power. The vacuoles are colorless and are probably only drop-like accumulations of cytochylema. In the nucleus the karyochylema is perfectly colorless and through it runs a net-work of chromatin which appears to have thickened nodes. A nucleolus, which stains but very slightly, usually occupies a central position. By focussing the distribution of the chromatic reticulum is distinctly seen to be peripheral and not suspended in the karyochylema. When only the equatorial plane of the nucleus is in focus the thick masses of chromatin are seen to be closely applied to the wall of the nucleus — only a few of them running out into the limpid karyochylema. The thin strands of chromatin connecting the irregular masses probably also run along the inner face of the nuculear wall. Fig. 5 represents five nuclei drawn with the focus on their equatorial planes. In the interior of the karyochylema the nuceoli stand out distinctly as bodies which stain much less deeply than the mass of chromatin.

The nuclei retain their characteristic structure apparently without the slightest alteration till the complete dissolution of the appendage on about the twenty-seventh day of development. When at that time the nuclei cease to stain, the chromatin [probably now of modified molecular structure] is still visible in glistening masses distributed as formerly. The nucleolus, too, is still seen as a less refractive body of greater dimensions than any of the irregular chromatin masses.

The cells of the lower part of the appendage in embryos fourteen days old [Fig. 3], do not differ in form from the ectoderm cells in general. They lengthen somewhat and clasp the inner ends of the large prismatic cells which form the great mass of the now nearly solid pleuropodium. These smaller ectoderm cells thus form a broad tubular peduncle, the lumen of which is in free communication with the body cavity of the embryo.

The next changes which may be noticed in the appendages [in embryos about nineteen days old] are superficial and easily described. The tubular peduncle increases in length with a resulting decrease in the breadth of its lumen. At the same time the portion of the segment to which the appendage is attached is carried upward and comes to lie somewhat dorsad to what will be the coxa of the metathoracic leg. While this movement is taking place a constriction appears [Fig. 6 *cn.*] dividing the bulbous mass of large prismatic cells into two segments. This constriction is merely su-

perficial and does not divide the cells transversely. The nuclei are seen to have moved back from the periphery of the appendage and to lie, several rows deep in the basal half of the apical, and in the apical half of the basal metameres into which the organ has been constricted. The contour of the inner ends of the prismatic cells has become more distinct and the cavity into which the lumen of the peduncle opens has become larger. The peripheral ends of the prismatic cells are full of oval vacuoles of about equal size, placed side by side. They occupy the whole surface of the apical metamere. [Fig. 6 *v.*] Perhaps these vacuoles, as also those described in a preceding stage, may be caused by the action of reagents, though the regularity of their occurrence and the lack of vacuoles in other tissues of embryo *Blattæ* killed and prepared according to a method described in a former paper ['89*c*], seems to preclude the belief that they are artefacts. Be this as it may, their presence would seem to indicate that the cytoplasm of the outer ends of the prismatic cells is of a different, perhaps more sensitive, structure than that in the remaining portions of the cells.

The appendage has now reached the highest point of its development and henceforth slowly advances towards dissolution. By the twentieth day [Fig. 7] it has become more or less irregular in outline. The peduncle [*pd*] has increased in length and tenuity; the cavity [*cv.*] has become irregular owing to the basal edges of the prismatic cells becoming ragged, and the constriction is disappearing. In the appendage figured it is still seen as a deep indentation on one side [*cn.*]; on the other side no traces of it are visible. The shape assumed by the organ is now no longer constant in any two individuals. The vacuoles have either entirely disappeared as in Fig. 7, or they are much elongated and usually found between the prismatic cells. Where the lateral walls of the cells have disappeared their former position is often marked by these elongate vacuoles. From being intracellular as in Figs. 3 and 6, the vacuoles thus become intercellular just before disappearing.

On about the twenty-fourth or twenty-fifth day the cuticle covers the whole surface of the embryo. No cuticle, however, forms on the surface of the pleuropodium, the elongate peduncle of which is constricted off by the developing chitinous secretion. When embryos of this age are kept for hours or even days in hæmatoxylin or borax carmine and then washed, it is found that in perfect specimens none of the staining fluid has penetrated the cuticule; the embryo is still yellowish white, with a brilliant violet or red spot, visible to the naked eye just behind the base of the metathoracic leg on either side of the body. This is the pleuropodium, the only portion of the embryo which has been stained by such protracted immersion.

Examination with higher powers shows that the pleuropodium has now become very irregular in outline. [Fig. 8.] The old boundaries between the prismatic cells have disappeared. The apical part of the appendage, still somewhat bulbous in shape, is a syncytium through which the nuclei appear to be migrating toward the opening of what was formerly the pe-

duncle but which has now broken down into a mass of cells of more or less irregular outline [Fig. 8 *n.*]. This mass of cells is augmented by the nuclei which are continually leaving the bulbous mass of protoplasm, and which, before they leave it, surround themselves with an irregular body of cytoplasm cut from the large mass of protoplasm. This process continues while the whole mass of cells takes on various forms. Finally it spreads out between the posteriorly directed metathoracic leg and the ventral face of the abdomen. Fig. 9 shows a section through the remains of the pleuropodium of an embryo twenty-six days old. The nuclei fail to stain more deeply than the protoplasm. The mass *pl* seems to be the remains of the bulbous portion marked *pl* in Fig. 8. In embryos a few hours older no traces of the organ are to be found. Its remains probably become indistinguishable from the granular plasmatic secretion which is found in coagulated masses about the legs and mouth-parts of the embryo. This granular plasma was originally the limpid fluid that filled the cavity of the amnion.

It will be seen from my description that the origin, development and dissolution of the pleuropodia is comprised within the space of fifteen days—from the twelfth to the twenty-seventh day of the whole period of development, which requires about a month. Within these fifteen days falls the peculiar phenomenon of revolution, which begins on the fifteenth and is concluded on the seventeenth day. Fig. 1 illustrates the lateral view of an embryo during revolution. [Sixteen days old.] The appendage [*ap.*] has reached its maximum size and already shows the constriction which is most marked a few days later. The amnion and serosa have ruptured and are passing back over the large mass of yolk. The serosa, *s*, with its large flat nuclei is contracting away from the ventral and posterior portions of the yolk. The amnion, *a*, with its much smaller nuclei still covers the ventro-lateral faces of the egg in continuity with the edge of the dorsad growing body-wall.

For a more complete account of the revolution of the embryo I would refer the reader to a former paper ['89c].

Periplaneta orientalis. L.

(Plate II, Fig. 10.)

So great has been the difficulty encountered in removing the large eggs of this Blattid from the thick-walled ootheca in which they are deposited, that I have succeeded in securing only a few advanced embryos.

As would be expected from the close systematic affinities of the insects, the pear shaped pleuropodia are similar to those of *Blatta*, though they are somewhat more truncated at their ends and attached by much shorter and broader peduncles than in the species dealt with above. Fig. 10 represents a longitudinal section through one of these appendages as it appears in a cross section through the middle of the first abdominal segment. The

greater portion of the body is still filled with yolk [not seen in the figure], while a portion of the mesoderm has been converted into connective tissue, *ms*. The pleuropodium is undergoing degeneration. We have seen that in *Blatta* the nuclei of the huge cells so characteristic of the organ are at first distal in position, but that they gradually wander back towards the body during the breaking down of the appendage (Fig. 8). A like migration of nuclei seems to occur in *Periplaneta*, though I cannot affirm this with certainty as I have seen only pleuropodia in the stage figured. Certain it is, however, that many of the nuclei lie in the proximal ends of the cells. The shape of cells so closely applied to one another as those under consideration must be determined to some extent by the position of their large nuclei. Now in Fig. 10, the broad ends of the cells are directed towards the body, while the narrow ends converge at a point [*t*] in the distal end of the appendage. This is probably not the original arrangement, which would be like that seen in *Blatta* [Fig. 3]. In order to reach the condition of the advanced pleuropodial cells of *Periplaneta*, from the condition seen in *Blatta* in a younger stage, we have only to suppose that most of the nuclei migrate to the proximal ends of their respective cells and push before them a quantity of protoplasm; in this way the cells would become rounded off at what were originally their pointed ends, and taper to thread like points at what were before their broad distal ends. At *x* two such cells are seen in the act of loosening themselves from the main mass and are apparently about to pass into the body cavity through the broad lumen of the peduncle. The cells with more deeply stained nuclei at *y*, agreeing with the cells of the ectoderm, *ecd*, and contrasting with the large pleuropodial cells, seem to belong to the common ectoderm; they at first, perhaps, form the walls of the peduncle but subsequently pass up into the appendage. This supposition is rendered more probable by their peripheral position. The ends of the large cells are frequently filled with and separated from one another by vacuoles, some of which are very large and conspicuous. The protoplasmic reticulum in the neighborhood of these vacuoles has the striated appearance described above for *Blatta*. At the distal end of the pleuropodium the protoplasm is less compact and in many of my sections, like the one figured, spreads out in an irregular granular mass which leaves the appendage and probably joins the amniotic coagulum. If my interpretation of the few stages which I have seen is correct, the pleuropodia of *Periplaneta* disappear partly by absorption into the body of the embryo and partly by the dissolution of their outer portions between the body walls and the egg-envelopes. In the section figured the cuticle [*ct*] is formed on the pleural and ventral walls of the abdomen, but is not continued over the surface of the pleuropodium.

Mantis carolina, L.

(Plate II, Fig. 11.)

Mr. T. H. Morgan has kindly sent me some of the embryos of this interesting insect. All the specimens examined were in a stage just preceding the rupture of the embryonic envelopes, hence almost corresponding with the *Blatta* embryo figured (Fig. 1). The pleuropodia are distinctly visible in surface view as a pair of narrowly pyriform evaginations, partly covered by the metathoracic legs with which they are homostichous. Their tips are directed laterally, while the ends of the metathoracic appendages converge towards the median ventral line. Each pleuropodium is very much shorter and narrower than the legs or any of the cephalic appendages. A section [Fig. 11] shows that the organ is a solid body, perhaps best described as a narrow, pear-shaped sack, whose thickened walls are made up of a single layer of cells and whose cavity has been reduced so as to be represented by a line. The cells forming the appendage have the form of curved pyramids; their broad bases form the outer surface and their gradually tapering apices converge from all sides towards the central line representing the obliterated cavity. These cells differ only in shape from those of the ectoderm of the body walls and other appendages: the size and reactions of the nuclei together with the quantities of cytoplasm surrounding them are essentially the same in the elements of both the body walls and pleuropodia. In the pleural wall [*ecd*] the nuclei are arranged in about three irregular rows; just at the insertion of the pleuropodium, however, there is only one row, a fact indicating that the appendage, which was very probably hollow in a preceding stage, had its lumen shut off from the body cavity by the intrusion of a layer of ectoderm cells at x. Not having studied more advanced embryos, I am unable to state anything in regard to the manner in which the pleuropodia degenerate. The fact that these organs are small and solid and that their component cells differ in no way from the ectodermic elements of the body walls and other appendages, is sufficient proof that the pleuropodia of *Mantis* are mere rudiments.

In *Mantis carolina* there are distinct appendages on at least the second, third and fourth abdominal segments, but none of these in my embryos had developed beyond the mammillate stage. *Graber* ['88] has observed on the second abdominal segment of an European *Mantis* a pair of appendages shaped very much like the pleuropodia on the basal segment. As these do not occur in all embryos of the European species, and as the embryos of the American species examined by me, were all taken from a single capsule and hence deposited by a single female, I cannot feel certain that this second pair of pleuropodia is always or even normally absent.

Xiphidium ensiferum, Scud.

(Plate 2, Fig. 12, 13, 14.)

The ontogeny of this interesting insect presents a remarkable and apparently isolated retention of many annelid traits. Among other peculiarities there is developed in an early stage a large and rounded preoral disk between the procephalic lobes, making the head of the embryo resemble a clover leaf. This preoral disk is soon completely constricted off from the body of the embryo proper, and, moving forward a short distance, gives rise to two cellular envelopes. The movements of the embryo in relation to the yolk also differ markedly from anything heretofore described in insect development. As I shall devote a special paper to a description of the development of the *Xiphidium* embryo, I will here confine my attention to the pleuropodia which are quite as prominently developed as in other Orthoptera.

The embryo when first formed on the convex surface of the curved elongate- oval egg, resembles very closely the *Blatta* embryo which I have figured in a corresponding stage ['89*c*, Plate XVII, Fig. 45]. The appendages of the first abdominal segment arise as in *Blatta*, but as soon as the differentiation of their component cells sets in, a great difference between the Blattid and Locustid pleuropodia becomes apparent. Each of the modified appendages becomes bulbous and constricted into a peduncle at its base; the contour, however, is not evenly rounded but somewhat angular. The distal end of the sack terminates in a point. Sections show that the cavity of the organ is very large [Fig. 12, *cv.*] while the cells forming the walls are consequently reduced to short and broad prisms. Their cytoplasm, though still distinctly granular, is paler than that of the ectoderm cells of the thoracic appendages and body walls. The nuclei, too, stain much less deeply than the much smaller nuclei of the remaining ectoderm, presumably because the quantity of cytochylema is relatively much greater, while the amount of chromatin in the modified and unmodified ectoderm remains approximately constant. At first the large cavity of the pleuropodium communicates with the body cavity by means of a canal through the peduncle: later this communicatiou seems to be completely cut off by the disappearance of the lumen.

While the cells of the pleuropodia are differentiating to reach the stage figured [Fig. 12] and described, the embryo passes through the yolk backwards and emerges tail first on the concave surface of the egg. Here it grows considerably and then during revolution passes around the posterior pole of the egg and again makes its appearance on the convex surface of the yolk. During the time that the embryo is going through these peculiar maneuvers, the pleuropodia reach their maximum size and advance towards the pleuræ. Henceforth they diminish in size while their peduncles become thinner. The oldest embryos examined had their eyes

pigmented and were ready to escape from their envelopes. When the chorion was removed, the serosa and first cuticle were found covering the embryo, the hypodermis of which had already secreted a second chitinous layer. The shrunken but still conspicuous pleuropodia were attached to the pleuræ laterad and close to the insertion of the saltatorial leg. A dark brown granular substance was collected in large masses over the head of the embryo, in the spaces betweeen the legs and the envelopes and on the surface of the pleuropodia, both of which were easily torn from the body and left adhering to the serosa and first cuticle. To these membranes also adhered much of the granular dark brown secretion. When I attempted to stain embryos still in possession of their pleuropodia, I made the same observation as on *Blatta* embryos of the corresponding stage: the pleuropodia were colored but the chitinous covering of the remainder of the body prevented the stain from entering the subjacent tissues. Sections through the first abdominal segment of embryos in this advanced stage [Figs. 13 and 14] show that the peduncle of each pleuropodium is much attenuated and inserted *on* the cuticle at the bottom of a rather deep pit in the pleural hypodermis [*ecd.*]. The appendage is therefore cut off from the living tissues of the body and, being very loosely attached, is easily shed by the embryo during the movements preparatory to hatching. A section through the broad portion of the organ in the present stage [Fig. 14] when compared with a section of the organ in its prime [Fig. 12] shows the extent of dissolution. The cell boundaries, faint but still perceptible in Fig, 12, have now disappeared and the organ has become a syncytium. Those portions of the cytoplasm which border the central cavity [*cv.*] are filled with numerous vacuoles of different sizes. The nuclei have lost their regular arrangement, and in many cases also their evenly oval contours; their cytoplasm stains more deeply and their chromation is aggregated to form larger masses. The granular secretion [*s*] surrounding the organ and filling such spaces as are left between the embryo and its envelopes stains deeply in hæmatoxylin and seems to be a later formation than the homogeneous secretion indicated at *as* in Fig. 12, between the amnion and body of the younger embryo. The abundance of this granular substance clinging to the walls of the shrunken pleuropodia and heaped about the legs in the immediate vicinity would seem to indicate that it is to be regarded as a secretion of the pleuropodia or of one of the embryonic envelopes and not as the decomposed amniotic secretion.

Cicada septemdecim. Fabr.

(Plate 3, Figs. 19 and 20.)

Most entomologists are familiar with the small ova deposited by this noxious Homopteron in short parallel rows in the twigs of our native trees. The eggs are translucent, so that the stages of embryos killed in Carnoy's fluid heated to 70° C., which renders the yolk transparent and the embryo

opaque white, may be readily recognized before sectioning. It is difficult to remove the chorion without seriously damaging the egg, so that sections are best stained on the slide. The development is very much like that of *Aphis* as described by *Will.* ['88.] This need not surprise us when we stop to consider the close relationship of the Phytophthora and Homoptera.

In the earliest stage examined the embryo was found in the middle of the yolk, with the thoracic appendages just making their appearance, and the thin amnion so closely applied to the ventral plate as to be difficult of detection in some sections. The embryo is quite straight, exhibiting little of the pronounced curvature of the *Aphis* embryo.

In a later stage when the thoracic and cephalic appendages are well established, no appendages are to be observed on the abdominal segments, sections through which show that the ventral surface is very flat, without even the bulgings that have frequently been mistaken for rudimental appendages. In a cross section through the middle of the first abdominal segment [Fig. 20] there is seen at the points corresponding with the places of evagination of the metathoracic appendages of the preceding segment, a pair of ectodermic thickenings [*ap*]. The cells of these thickenings as shown by the curvature of their nuclei are aggregated somewhat like the segments of an orange. The long axes of all the ectoderm cells are in this stage directed dorso-ventrally. I have for the sake of emphasis represented the thickenings, which for reasons given below, I believe to be true homologues of the evaginated pleuropodia of other insect embryos, as paler than the cells of the surrounding ectoderm, though in reality no such differentiation has as yet set in. In the section figured a slight depression marks the convergence of the outer ends of the pleuropodial cells.

During the revolution of the embryo the pleuropodium reaches its full size and presents in section the appearance of Fig. 19 *ap.* It is easy to see how this organ originates from an orange-shaped cluster of cells like that just described. The ectodermic elements increase greatly in length and assume the form of curved pyramids with their tapering apices attaining the surface of the body and their broadened nuclear ends projecting into the body cavity. The outer and attenuated ends of the cells are uniformly hyaline and stain very faintly in borax carmine. The cytoplasm of the inner ends is granular like that of the remaining ectoderm. [*ecd.*] The nuclei of the pleuropodium seem not to differ in their finer structure from the nuclei of the general ectoderm. They are frequently triangular or violin-shaped both in the pleuropodium and in the undifferentiated ectoderm. The only difference is one of position: the nuclei of the body wall lie at right angles to their former position. A granular mass, the amniotic secretion, fills the space between the body walls and the egg membranes [*ch.*] In one place, however, this mass is replaced by one of a different nature, a glairy, homogeneous and vacuolated substance [*s*] of irregular though rounded outline, firmly attached to the attenuated tips of the pleuropodial cells. This homogeneous mass, which stains pink in borax carmine, is often more

globular than as represented in the figure, and is often separated from the granular amniotic secretion by a clearly defined space, proving that one or both of the secretions contract under the influence of the reagents employed. From the constancy of its occurrence and the manner of its adherence to the outer surface of the pleuropodium, I do not hesitate to regard the homogeneous mass as a secretion of the pyramidal cells. It seems to consist of an albuminoid substance; the vacuoles which it contains may be artefacts. Not having examined it in fresh embryos, I was unable to learn anything more concerning its physical or chemical nature.

A somewhat more advanced embryo was examined in surface view after staining with Ehrlich's haematoxylin. The presence of the pleuropodium was distincly indicated on each pleura of the first abdominal segment near the insertion of the metathoracic leg, by a clear circular area surrounded by a dark ring. The clear area I take to be the cluster of hyaline cell-tips; the appearance of a dark circle is probably due to the ectoderm cells seen in section at *o o* together with the nucleated ends of the subjacent pleuropodial cells.

In *Cicada* embryos nearly ready to hatch the pleuropodia are not to be found. The pyramidal cells grow pale and irregular, finally fall asunder and are probably absorbed. The ectoderm cells at *o o* grow over the small area formerly occupied by the hyaline cell-tips to complete the pleural wall.

Although the pleuropodia of *Cicada*, being invaginated thickenings of the ectoderm, differ considerably from the evaginated pleuropodia of the Orthoptera, I believe that I am justified in regarding both forms as homologues. The facts which make for this homology are the following:

1. The pleuropodia of *Cicada* are of purely ectodermic origin.
2. They appear only on the first abdominal segment.
3. They are at first homostichous with the thoracic and cephalic appendages.
4. Their cytological structure closely resembles that of some evaginate pleuropodia; the shapes of the component cells with reference to the surface of the body being merely reversed. Compare the pleuropodia of *Mantis carolina*. [Fig. 11.]
5. Their greatest development is attained during the revolution of the embryo.
6. They move away from the median ventral line of the embryo and take the same position on the pleuræ as the evaginated pleuropodia of the Orthoptera and Coleoptera.
7. They atrophy and disappear before the embryo hatches.

Zaitha fluminea, Say. *

[Plate 3 Figs. 17 and 18.]

Of this form I have examined only embryos in the stages immediately preceding, during, and after revolution. Just before revolution the embryo lies on one face of the yolk with its amnion and serosa in contact and not separated by a layer of the vitellus as in most of the Hemiptera whose ontogenies have been studied. Hence *Zaitha* would seem to resemble the Orthoptera and Coleoptera in its manner of embryo formation. The stages which I have studied show only the fully developed pleuropodia; I can, therefore, assert nothing in regard to the process whereby these organs originate and disappear, although their resemblance when fully formed to the pleuropodia of *Cicada* renders it highly probable that the beginning and end of their development are no less similar to those observed in the Homopteron.

In Fig. 17 I have represented half a cross-section through the first abdominable segment of an embryo during revolution. The ectoderm [*ecd*] of the dorsal surface in the neighborhood of the heart [*cb*] is much thinner than the ectoderm laterad to the large ganglion [*gl*]. In one place near the large pleural fold filled with adipose cells [*ad*] the ectoderm is greatly thickened to form a bulbous organ which is to be regarded as a pleuropodium. The cells composing it are greatly elongated, being three or four times as long as the thickest ectoderm cells of the ventral body wall. It is also seen that a great number of cells take part in the formation of the *Zaitha* pleuropodium while but very few go to make up the same organ in *Cicada*. In the water-bug the rounded inner face of the pleuropodium projects as far as the yolk and presents at irregular intervals a few flattened mesodermic elements [*cn*]. The inner ends of the long cells are coarsely granular, their outer ends uniformly hyaline. Their nuclei are but little larger than the nuclei of the body walls. The delicate hyaline cell-tips converge to form a flat surface which is covered

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* The eggs of this species were given me by Dr. W. Patten as the eggs of an aquatic Hemipteron, which from his description I took to be a *Nepa*, and mentioned it as such in my preliminary notes ('89*a* '89*b*). The species, however, can be no other than our common *Zaitha fluminea*, Say, for I now remember Dr. Patten telling me that he found the eggs attached to the hemielytra of the female. This habit, according to *Uhler* (article *Hemiptera*, Standard Natural History Vol. II, p 258, 1884) is shared, so far as their habits have been observed, by all the species of this exclusively American genus. The female *Nepa* attaches her eggs to aquatic plants. The chorion of the egg is smooth and unornamented in *Zaitha*, while the egg of *Nepa* has at one end seven hair-like radiating processes, which, according to *E. v. Ferrari*, make the egg resemble the seed of *Carduus benedictus*. (Die Hemipteren-Gattung *Nepa*, Latr (sens. natur.) Annalen d. K. K. naturhist. Hofmuseums. Bd. III, No. 2. Wien 1888.)

I hasten to correct my mistake, as the species of *Nepa* and *Zaitha* are not only generically distinct, but belong to different families: the former to the *Nepidæ*, the latter to the *Belostomatidæ*.

by a broad pencil of refractive threads [*s*] which is to be regarded as the secretion of the pleuropodial cells. In Fig. 18 three of these curious cells are represented as they appear under a magnification of about 900 diameters. The inner ends which stain deeply in borax carmine contain a number of very coarse granules among which are interspersed a multitude of finer ones; the granules diminish in number beyond the oval nuclei and have completely disappeared in the gradually tapering outer ends of the cells [*l*]. These ends are not affected by the stain. Each cell-tip is capped by a refractive thread, which nearly or quite equals the cell in length and may often be split into two or three branches. Usually the line which separates the cell-tips from the threads which cap them, is distinctly marked as in Fig. 17 and at *z* in Fig. 18. I have, however, found numerous cases where no such line could be detected, the hyaline cell-tips passing without interruption into the long refractive threads. The minute structure of the nuclei resembles that of the pleuropodial nuclei of *Blatta*. Through the faintly stainable caryochylema runs a chromatic reticulum, the nodes of which are irregular and much thickened. The nucleolus has little affinity for staining fluids and is probably to be relegated to *Carnoy's* class of "nucléoles plasmatiques."

Sialis infumata, Newm.

This Neuropteron oviposits on the leaves of plants overhanging the water. The eggs are arranged in regular rows, with their stem-shaped micropyles directed upwards. The embryos are so small that it is difficult to obtain good surface views; still I have been able to satisfy myself that the first abdominal segment, at about the time of revolution, presents a pair of conical evaginated pleuropodia, which lie somewhat outside of the line of the thoracic legs. In my sections I could detect neither a differentiation of the cells nor diverticula of the body-cavity extending into these appendages. The apparent solidity of the organ may have been due to the thickness and the plane of my sections.

PART SECOND.

Gryllotalpa vulgaris. L.

The pleuropodia of the mole-cricket were observed as early as 1844 by *Rathke* ['44] who described them as mushroom-shaped bodies. Many years later, *Korotneff* ['85] in his account of the general embryology of *Gryllotalpa* figured and described the same organs more at length. According to this author they arise as button-shaped prominences, not in line with the other appendages but laterad to them. Their outline in section resembles that of a mushroom and they are seen to consist of succu-

lent [saftigen] cells. Later, when the back of the embryo has closed over, these appendages atrophy ["gehen zu Grunde"]. They fall off and disappear completely. ["Sie fallen spurlos ab"].

It may be doubted, judging from observations on other Orthoptera, whether the pleuropodia arise laterad to the other appendages. Probably the earliest stages in their formation escaped *Korotneff*. His last observation, viz.: that the pleuropodia fall off, is quite definite, and, if based on observation, precludes their possible disappearance by absorption.

Oecanthus niveus, Serville.

The second insect in which pleuropodia were described was *Oecanthus niveus*. *Ayers* ['84] while pursuing the general ontogeny of this Gryllid was evidently impressed with the interest attaching to these organs; hence the more complete account which I reproduce in full:

"The respiratory function of the embryo is first indicated at the time of revolution by the appearance of paired lateral outgrowths of the ectoderm from the pleural region of the first abdominal segment. These gills or respiratory organs come to lie just behind, but dorsad of the base of the third thoracic appendage. In outline they are broadly oval or kidney-shaped and are united to the body by a short peduncle springing from the center of that face of the disc which is in contact with the body of the embryo. These folds are cellular structures and at different periods are solid or hollow. The cells of the folds early lose their ectodermic characters and become somewhat larger than those of the adjacent body wall. In the fresh condition they appear enucleate and coarsely granular, but upon treatment with osmic or acetic acid a nucleus is distinctly visible. In surface view there is to be seen a clear central area which indicates the position of the internal cavities of the gill. These cavities are continuous with the body cavity and probably serve as channels through which the vascular fluid circulates They vary in shape and relative proportions. The relations of these appendages to the body is best seen in sections. The outgrowing flap is here seen to project over an invagination immediately below it and in some instances to become apposed so closely to the body wall as to convert the open pocket into a closed canal. In its middle part, where the fold fuses with the body, its cells are separable into two irregular layers which correspond to the two primitive plates of the fold, but they fuse completely, or become widely separated, in the free portion of the pad. These appendages reach their greatest degree of development soon after the revolution of the embryo, and then gradually atrophy, entirely disappearing before the complete closure of the body walls. In sections of the gill organ before its atrophy [or absorption] one finds both distinct canals and lacunar spaces, which radiate from the point of connection of the pad with the body, and these together with the arrangement of the cells give the radiate structure characteristic of the fresh gill. The canals

are generally circular in section and pursue irregular courses throughout the cell substance, while the spaces are developed by the separation of adjacent cell walls and are irregular in outline and occur at varying distances from each other. The gill pad is essentially a single-layered sac, with a much constricted neck, evaginated from the pleural region of the abdomen. The protruding organ is flattened against the body of the embryo and by this means the cells are rendered spindle-shaped. The nucleus of each cell lies in that part of its cell which is farthest from the constriction of the organ. The cell wall gradually tapers to a point and ends near the neck. The cells are bent in various ways depending upon the relations of their nuclei to the wall of the pad."

Ayers seems not to have recognized the identity of the abdominal appendages and what he calls the "gill-pads." On plate 18 he figures [Figs. 8, 19, 20, 23, ab. p.] the first pair of abdominal appendages as digitiform and arising in a line with the thoracic and remaining abdominal appendages. In Fig. 20 these organs are seen with tips directed outward, while the ends of the thoracic appendages converge. Concerning the abdominal appendages he writes:

"Soon after the mesoderm has extended into the hollow appendages, there appear successively a varying number of abdominal protuberances exactly similar to the maxillary and thoracic appendages in their earliest stage of growth. Of these only two pairs ever reach any considerable degree of development, they are the first and the last abdominal. The former grows to the length of the mature mandibles and then atrophies. It varies in shape from a finger-like process [pl. 18, fig. 17] to a lobed outgrowth, and in the later stages is covered by the last thoracic appendage."

The last sentences imply that the organ undergoes dissolution *in situ* and this is further sustained by Fig. 22, where what would seem to be the irregular remains of the appendages are seen through the translucent metathoracic legs. Evidently *Ayers* lost sight of the appendages after they had been covered by the last thoracic legs and when they passed out from under these and made their appearance as enlarged and peculiarly modified organs high up on the pleural wall, they were regarded as organs having no relation to the abdominal appendages. *Ayers* no longer letters the appendages with ab. p., but with a new reference, λ, and, what is more conclusive, says that the pleuropodium "is essentially a single-layered sac with a much constricted neck, evaginated from the pleural region of the abdomen."

The section of the "gill" described and figured by *Ayers* [Figs. 13 and 14, pl. 22] "before its atrophy [or absorption]" shows the cells after the setting in of degeneration. The figures are in every way comparable to the figure which I have given of *Periplaneta* (see above, page 92, also fig. 19, Plate II). Fig. 14 shows the dorsal wall of the embryo covered over and the heart completed, a stage in which the pleuropodia have passed beyond their maximum development which is attained just before

or during revolution. The canals and spaces alluded to in *Ayers'* description are exactly like those seen in *Periplaneta* in the corresponding stage, and must not be regarded as delicate ramifications of the body cavity but as irregular spaces produced by the falling asunder of the columnar cells. They are probably identical with the intercellular vacuoles seen in the degenerating pleuropodia of *Blatta* and *Periplaneta*. Had *Ayers* passed sections through the pleuropodia of *Oecanthus* before the setting in of dissolution, his description would have been different and very probably like what I have given for *Xiphidium*.

Stenobothrus.

Graber briefly described the pleuropodia of this Acridian in his paper on polypody ['88]. In a more recent article ['89] he gives a fuller description which I reproduce:

"Each of the pleuropodia of *Stenobothrus* at the time of its greatest development lies on the pleural wall of the first abdominal segment about where, in later life, the tympanal apparatus is situated. It is a flattened biscuit-shaped body about 1 mm. in diameter. While the remainder of the body wall remains destitute of pigment till the insect hatches, the pleuropodia acquire a brownish hue. Of the same color also is a finely granular coagulum partly glued to the skin in the immediate neighborhood of the pleuropodia and the legs. In sections the organs present a wide cavity which opens by means of a short and rather broad passage into the body cavity. In some sections a few cells, probably interpretable as blood corpuscles, are to be found in the cavity; in other sections these cells are absent. The large cells of the outer wall, which in this insect also are enormously developed, are especially interesting, as they are so filled with yellowish granules that the whole outer wall of the sack presents the appearance of a brownish yellow plate. These granules are visible even in Canada balsam preparations. Closer observation shows that the above mentioned coagulum in the vicinity of the pleuropodia and legs contains yellow granules very similar to those contained in the cells and thus justifies the conclusion that this coagulum, at least in part, is secreted by the pleuropodial cells, the outer surfaces of which are not covered by a chitinous cuticle."

Blatta germanica, L.

Patten was the first investigator to describe the pleuropodia of *Blatta germanica* ['84]. His observations are summed up in the following words:

"At first a number of abdominal appendages are developed which, however, quickly disappear again with the exception of the first pair, which further develops into pear-shaped structures attached to the abdomen by a stem that increases in length and finally changes into a very fine duct leading into a small cavity in the expanded distal extremity, which owes

its size to the development of extremely high ectoderm cells. No mesodern enters into the construction of the peculiar organ which in the later stages of development disappears entirely."

Cholodkovsky's paper ['89] which in respect of the pleuropodia of *Blatta* adds but little to *Patten's* description, appeared several months after my account of these organs was written. After describing the origin of the different appendages, the Russian observer passes to a more detailed description of the first abdominal pair.

"While the ectoderm cells keep increasing in length in the first abdominal appendages, those of its constricted basal portion, on the contrary, become somewhat shorter. As a consequence of these changes the abdominal appendage assumes the shape of a pear attached to the body by means of a slender stem only. The greater portion of such an appendage consists of very long and narrow, almost fusiform ectoderm cells, which with their broadening distal ends form the surface of the appendage, while their proximal ends narrow towards the peduncle. The cells are very closely applied to one another, and there is no cavity in this portion of the modified appendage, though there is a narrow canal in the axis of the peduncle leading into the body cavity. Somewhat nearer its distal than proximal end each long ectoderm cell contains a large oval nucleus. Focussing on the surface of the widened portion of the pear-shaped body one observes that it is divided into facets; each facet has slightly raised edges and a central depression, and belongs to an ectoderm cell. During later development before the hatching of the embryo these appendages disappear by a process unknown to me."

This description is in the main correct. It is true that the outlines of the pleuropodial cells are polygonal in surface view, but I have never seen anything like the facets with raised edges and depressed centers described by *Cholodkovsky* and depicted in his Fig. 15 This appearance is probably due to *Cholodkovsky's* method of preparing *Blatta* embryos by protracted immersion in Perenyi's fluid, a method which is in all probability responsible for the marked distortion of some of his other figures.

Mantis.

To *Graber* we owe the only account of abdominal appendages in *Mantis* embryos published heretofore. In his general work on insects ['77] he figures the anterior portion of a young *Mantis* embryo, in which the pleuropodia are seen as a pair of digitiform processes, directed and shaped like the thoracic legs, which they are far from equalling either in length or breadth. In his later paper ['88] *Graber* figures another embryo *Mantis* in which is seen a pair of what might be called secondary pleuropodia on the second abdominal segment. This second pair, which is absent in some embryos is somewhat smaller, though in other respects exactly like the first pair. Further stages in the development of these organs are not described.

It is probable that they soon disappear without ever becoming bulbous, since a tendency thus to differentiate is distinctly manifest in other Orthopteran embryos that have reached the age of the *Mantis* embryos figured by *Graber*.

Neophylax concinnus.

An isolated observation on pleuropodia in the Phryganeidae is embodied in one of *Patten's* figures of a *Neophylax* embryo ['84, plate 36 A, Fig 11.] *Patten* notes the fact in the text [page 578] that three pairs of abdominal appendages are developed on the basal segments, but says nothing about a differentiation of the most anterior pair. The figure referred to, however, shows that the conical abdominal appendages of the first abdominal segment are considerably larger than those of the two succeeding segments. Dr. Patten has, at my request, kindly taken the trouble to re-examine his sections, and informs me that the cells of the pleuropodia differ in structure from the unmodified ectoderm cells of the other appendages and the body wall of the embryo.

Acilius.

At my request, Dr. Patten has very kindly sent me the following description of the pleuropodia of this Dytiscid:

As in other forms so in *Acilius*, the pleuropodia arise on the first abdominal segment of the young embryo, as a pair of ectodermic evaginations, homostichous with the thoracic legs. Later, the distal end of each bulbous appendage, consisting of large columnar cells, is invaginated in the form of a cup. The nuclei are situated in the inner ends of the cells, each of which secretes at its tip a short refractive thread, which, with those of the neighboring cells goes to form over the invaginated area a thick, striated, cuticula-like layer. Dr. Patten remarks that this form of secretion may be compared with the pleuropodial secretion of *Zaitha*, the only difference being that the individual threads secreted are so short as to form together a continuous sheet, instead of a penicillate bundle.

These peculiar appendages, which of all described species most closely resemble the pleuropodia of *Meloe*, do not fall off during their period of degeneration, but are pushed into the yolk and absorbed.

Hydrophilus piceus, L.

The pleuropodia of this form were first observed by *Kowalevsky* [71.] They are distinctly seen in his Fig. 12, as digitiform processes, shorter than the metathoracic legs. Nothing is said of their differentiation. In the figure of an older embryo they are represented as a pair of smaller protuberances inserted on the pleurae near the bases of the metathoracic legs.

Heider ['89] in the first part of his beautiful monograph, figures the pleuropodia of *Hydrophilus* in several places, [Figs. 2 and 3 in the text;

Fig. 9, plate 2, Figs. 10a, 10b, 11 and 12, plate 8] not as digitiform, but as small bulbous organs with spherical contour, developed from a pair of small mammillar prominences. At the time of the rupture of the embryonic envelopes, they are but little larger than the terminal metameres of the metathoracic legs and show but little tendency as yet to move apart from the places where they arose in line with the metathoracic and remaining abdominal appendages. In sections of the last stages described by *Heider*, the beginning of a differentiation of the cells may be observed but the pleuropodia do not attain their greatest differentiation till a later stage of development. *Heider* reserves further description for the second part of his monograph.

Melolontha vulgaris, Fabr.

In the cockchafer the pleuropodia attain a much greater size than in any other insect heretofore studied. We are indebted to *Graber* for an excellent description of these remarkable organs. ['88.]

The pleuropodia are first seen in embryos twelve days old, and do not reach their maximum size till the twenty-second day. They are large flattened sacks attached by peduncles and, when fully developed, are much longer than the thoracic legs and about three times as broad. *Graber* thus describes the minute structure of the full-grown pleuropodium:

"In respect of histological structure, a feeble magnification shows that the condition of the abdominal appendages differs decidedly in many, if not in all, particulars from that of the legs. This is especially true of the outer, or ectodermic layer. For, while this layer in the legs, like that of the body wall and all the other appendages * * * * consists of relatively narrow cells with relatively very small [0,006 mm] nuclei and only sporadically inserted larger cells with large nuclei, nearly all the cells in the abdominal appendages, and more especially those forming the outer walls of these pocket-shaped organs, are of considerable size and are provided with nuclei more than twice as large as those of the remaining ectoderm, since they measure about 0,014 mm. Considering that, at the time when the organ was formed, the ectoderm nuclei were 0,008 mm in diameter, it follows that during the course of further development, the nuclei of the ordinary ectoderm become somewhat smaller, while those of the ectoderm of the abdominal appendages undergo a considerable increase in size. This increase is most pronounced in the outer wall of the appendage; a portion of the inner wall, as well as the short cervical portion, or peduncle, formed by constriction, having typical [i. e., small] ectodermelements." Within the cavity of the sacks "are found numerous cells of the same structure as those which occur in the body cavity and likewise in all the appendages. I regard it as an open question whether these elements, originating as they do from an evagination of the mesoderm, become wholly

dissociated and are ultimately to be regarded as blood cells, or whether they, in part at least, unite to form a loose tissue [lockeres Gewebe.]"

Graber has also observed the atrophy of the pleuropodia of *Melolontha*. Degeneration begins about eight days after the pleuropodia attain their maximum size. "In the embryo thirty days old, with the dorsum closed over and the cephalic and anal ends already strongly flexed towards each other, the organ has diminished in size, not only when compared with the legs, but absolutely. More striking, however, is the reduction of the abdominal appendages in the thirty-four day old embryo, which in consequence of its great increase in length, is already completely coiled up and has attained to maturity. Here the appendages in question, are nothing but minute scales, hardly as long as a segment, and half concealed in the aforementioned coagulum. They separate from the body with the slightest touch. Probably they are pushed off while the insect is leaving its envelopes, perhaps in consequence of rubbing against the same. In the hatched larva only the healed [verloethete] cicatrice of the peduncle is to be found."

Meloe proscarabæus. L.

After treating of the formation of the germ-layers of this Coleopteron in a former paper, *Nusbaum* devotes a more recent article ['89] to a description of the very interesting pleuropodia. I quote his description *in extenso:*

"The appendages of the first abdominal segment have up to the eighth day of development the form of roundish cylindrical sacks and consist, like the thoracic legs, of a single layer of cylindrical ectoderm cells surrounding a cavity in which may be seen a few loose mesoderm cells. On the eighth day of development each of these appendages differentiates into two parts: one basal and cylindrical, and one distal, which is spherical and somewhat pointed at the pole [outer end]. In the basal part the cavity persists as before, together with the loose mesoderm cells; in the spherical portion, however, the cavity disappears and is replaced by large and much lengthened cylindrical cells. These large cells arise by a kind of invagination of a portion of the ectodermic layer at the pole of the appendage. The cells of the invaginated portion grow very rapidly and soon take on the appearance of very large and characteristic elements, so loosely juxtaposited that narrow clear slits may be observed here and there between them. The edges of the invagination approach one another till there remains only a small aperture leading into a roundish cavity closed on all sides. On the tenth day of development the segmentation of the thoracic legs may be seen very distinctly; in each leg three to four parts, or segments may be distinguished, which are marked off by constrictions on the outer surface of the ectoderm. It is interesting to note, that the appendages of the first abdominal segment seem also to undergo a kind of constriction, so that I cannot concur in *Graber's* statement that "the abdominal

appendages are always unsegmented." For, in the above mentioned stage of development a distinct constriction of the ectoderm may be observed between the basal and distal portions; hence I believe that we are justified in regarding as segments the two parts of the appendage thus distinctly separated. On the twelfth day of development — sometimes even before — the plasma of the invaginated cells, whose roundish oval nuclei lie near the basal ends, acquire a very distinctly and finely fibrillar structure, resembling that of the epithelium of many excretory glands. In the above described cavity is collected a homogeneous, sticky secretion, which gradually swells out of the aperture in considerable quantity. It is easy to detect delicate threads of this secretion running from the large cells surrounding to the mass of the secretion filling the cavity. The structure of these glandular appendages reminds me somewhat of the glandular temporary appendages ['dorsal organ'] which I have described in *Mysis;* I hasten, however, to state expressly that I do not wish to maintain any homology between these organs."

Interesting as is the account just quoted, *Nusbaum* goes on to describe a still more interesting condition. He says: "I have further convinced myself that the remaining stub-shaped abdominal appendages of *Meloe* are of a glandular nature. At the tip of each of these appendages there is also formed an invagination, which is, however, much shallower than in the appendages of the first abdominal segment, so that it does not form a cavity. The invaginated cells are closely juxtaposited, long and cylindrical but not as large as those of the first abdominal appendages. They likewise secrete a sticky substance, though in less quantity than the afore mentioned organs of the first segment. Back of these invaginated cells lies a cavity communicating with the body cavity and filled with loose mesoderm cells." The further fate of these organs was not traced by *Nusbaum.* "The roundish terminal joint of the appendages of the first abdominal segment is very probably thrown off, while the basal portion together with the stub-shaped appendages of the other abdominal segments gradually grow shorter, flatten out and finally disappear entirely."

Before passing to a brief resumé of the results recorded in the preceding portions of my paper, I insert a table of the insects, which have been studied with reference to abdominal appendages. In this list are included a few forms, in which no pleuropodia have been described. I am well aware that negative conclusions in regard to details merely read between the lines of works on the general ontogeny of a species are of very little value, but in the cases to which I allude, the probability of such prominent organs as the pleuropodia being overlooked by investigators who have carefully studied insect embryos by means of sections is so small, that I do not hesitate to record their omissions as negative results. Most of the forms enumerated as having no pleuropodia were examined by *Graber* and myself with the express purpose of observing whether these organs were present.

ORDER ORTHOPTERA.

FAMILY GRYLLIDÆ.

Oecanthus niveus, Serville.

pleuropodia evaginate, bulbous with reniform outline.

[*Ayers* '84.]

Gryllotalpa vulgaris, L.

pleuropodia evaginate, bulbiform.

[*Rathke* ('44), *Korotneff* ('85), *Graber* ('88).]

FAMILY LOCUSTIDÆ.

Xiphidium ensiferum, Scud.

pleuropodia evaginate, bulbiform, subreniform [*Wheeler*].

FAMILY ACRIDIIDÆ.

Stenobothrus.

pleuropodia evaginate bulbiform, with yellow granular secretion. [*Graber* ('88,) ('89)].

FAMILY MANTIDÆ.

Mantis (European).

pleuropodia evaginate digitiform: occasionally a pair on the second abdominal segment [secondary pleuropodia] [*Graber* ('77), ('88)].

Mantis carolina, L.

pleuropodia evaginate, elongate pyriform [*Wheeler*].

FAMILY BLATTIDÆ.

Blatta germanica, L.

pleuropodia evaginate, broadly pyriform.

[*Patten* ('84,) *Cholodkovsky*, ('89,) *Wheeler*.]

Periplaneta orientalis, L.

pleuropodia evaginate, pyriform [*Wheeler*].

ORDER HEMIPTERA.

FAMILY APHIDIDÆ.

No pleuropodia described for any of the following species:—

Aphis pelargonii. [*Will* ('88).]

" *saliceti.* [*Will* ('88).]

" *rosæ*, L. [*Will* ('88).]

FAMILY CICADIDÆ.

Cicada septemdecim. L.

pleuropodia invaginate, solid, bulbiform, with glairy, vacuolate secretion. [*Wheeler* ('89a, and '89b)].

FAMILY BELOSTOMATIDÆ.

Zaitha fluminea, *Say.*

pleuropodia invaginate, solid, bulbiform, with penicillate secretion. [*Wheeler* ('89a and '89b),].

ORDER COLEOPTERA.

FAMILY HYDROPHILIDÆ.

Hydrophilus piceus, L.

pleuropodia evaginate, digitiform.

[*Kowalevsky* ('71), *Heider* ('89)].

FAMILY DYTISCIDÆ.

Acilius.

pleuropodia evaginate, calyculate, with a thick, striated, cuticula-like secretion. (*Patten.*)

FAMILY SCARABÆIDÆ.

Melolontha vulgaris, Fabr.

pleuropodia evaginate, very large, flattened, bag-shaped [*Graber* ('88)].

FAMILY MELOIDÆ,

Méloe proscarabæus, L.

pleuropodia evaginate, calyculate, with sticky homogeneous secretion. [*Nusbaum* ('89).]

FAMILY CHRYSOMELIDÆ.

Lina tremulæ, Gmel.

no pleuropodia [*Graber*].

Doryphora 10-lineata, Say.

no pleuropodia [*Wheeler* '89].

ORDER NEUROPTERA.

FAMILY SIALIDÆ.

Sialis infumata, Newm.

pleuropodia evaginate, conical (*Wheeler*).

ORDER TRICHOPTERA.

FAMILY PHRYGANEIDÆ.

Neophylax concinnus.

pleuropodia evaginate, conical [*Patten* ('84)].

ORDER LEPIDOPTERA.

FAMILY BOMBYCIDÆ.

No pleuropodia have been observed in the following: —

Gastropacha quercifolia, L. [*Graber* '88.]

Bombyx mori, L. [*Tichomiroff* ('83)].

Orgyia leucostigma, A. and S. [*Wheeler.*]

Telea polyphemus, Cram. [*Wheeler.*]

Callosamia promethea, Drury. [*Wheeler.*]

Platysamia cecropia, L. [*Wheeler.*]

Hyperchiria io, Fabr. [*Wheeler.*]

ORDER DIPTERA.

No pleuropodia have been observed in the following:—

FAMILY CHIRONOMIDÆ.

Chironomus. [*Weismann*, ('63).]

FAMILY TABANIDÆ.

Tabanus atratus, Fabr.? (*Wheeler.*)

FAMILY MUSCIDÆ

Musca [*Weismann* ('63), *Voeltzkow* ('89)].

ORDER HYMENOPTERA.

FAMILY APIDÆ.

Apis mellifica, L.

No pleuropodia [*Buetschli* ('70), *Grassi* ('84).]

The facts accruing from a study of the pleuropodia in the above enumerated forms, representing some of the families of most of the natural orders of insects, may be briefly summarized as follows:

1. The pleuropodia were at one time organs of considerable functional importance to the primitive Hexapoda. This is proved both by the size which they attain in several cases [*Melolontha*, *Blatta*, *etc.*] and by the variety of structure which they exhibit in different species, sometimes even of the same natural order [*Hydrophilus*, *Melolontha*, *Meloe.*] The latter fact would indicate that the organs had occurred very generally among ancient insects and had undergone the modification to which the struggle for existence subjects organs of very general occurrence and important function.

2. Pleuropodia seem to be of constant occurrence in insects of some orders [Orthoptera, Trichoptera (?)], in other orders these organs are as constantly wanting [Lepidoptera, Hymenoptera], while in still other groups [Coleoptera, Hemiptera] they are well developed in some forms and entirely lacking in others.

3. The pleuropodia are always derived from the ectoderm.

4. They arise as appendages serially homologous with the appendages of the thorax and abdomen.

5. The pleuropodia described up to date belong to one of two types—they are either formed by evagination or invagination. Those of the latter type are subspherical and solid; those of the evaginate type appear under two forms: the bulbous and the calyculate, the latter being distinguished from the former by having the apical area invaginated. [*Acilius*, *Meloe.*] The evaginate bulbous form undergoes some modification in different species. Thus we may distinguish as its varieties the mushroom-shaped [*Gryllotalpa*], the reniform [*Oecanthus*], the broadly pyriform [*Blatta*], and the elongate pyriform pleuropodium [*Mantis carolina*]. All these varieties

are pedunculate. Undeveloped pleuropodia do not become bulbiform, since they never pass beyond the conical or digitiform phases common to all incipient insect appendages. [*Neophylax.*]

6. The cells composing the pleuropodia in all cases except where these organs remain rudimentary or digitiform, deviate considerably in their structure from the ectoderm cells of the body wall and the other appendages. The cells and nuclei increase in size and usually become more succulent.

7. In most pleuropodia of the evaginate type there is a larger or smaller cavity, communicating by means of a narrow duct through the peduncle with the body cavity [*Blatta*, etc.]. In the calyculate forms there is a second cavity, distinct from the first, opening in the opposite direction, on the outside of the body.

8. No tracheæ, nerves or muscles have been observed to enter into the formation of the pleuropodia. A few mesoderm cells, probably blood-corpuscles or fragments of mesenchymatous tissue, have been observed in the cavities of some evaginate pleuropodia.

9. In some species the pleuropodia produce a secretion from the ends of their enlarged cells. This secretion may be a glairy albuminoid substance [*Cicada*, *Meloe*.], a granular mass [*Stenobothrus*], a bundle of threads [*Zaitha*], or a thick, striated, cuticula-like mass (*Acilius*).

10. In some evaginate pleuropodia there appears a constriction, probably homologous with some one of the constrictions which separate the thoracic and maxillary appendages into metameres.

11. In some cases, at least, no chitinous cuticle is formed over the surface of the pleuropodial cells. [*Blatta*, *Stenobothrus*.]

12. The pleuropodia attain their greatest size during the revolution of the embryo. Soon after the yolk has been enclosed by the body walls and the heart has formed, the appendages of the first abdominal segment begin to degenerate.

13. The degeneration of an evaginate pleuropodium does not in all cases result in a reabsorption into the body of the embryo, but in a falling assunder of its large cells and their subsequent dissolution outside the insect's body.

14. The pleuropodia in all their forms and stages are characterized by a certain incompleteness, which, together with the brevity of their existence even during embryonic life, stamps them as mere rudiments of what were probably in remote ages much larger and more complex organs.

PART THIRD.

The question as to the original function of the pleuropodia must needs have suggested itself to all investigators who have met with these conspicuous organs in insect embryos. Naturally enough, each investigator has sought an answer in the particular insect studied, in most cases never suspecting that so simple an organ as a pleuropodium could have undergone much modification and have assumed in forms unknown to him a structure calculated to render his narrowly based theoretical conclusions untenable. In view of the ectodermic origin of the pleuropodia, they may be said to have had one of three functions: they were either respiratory organs, sense organs or glands. Hence, owing to the fact that limited observation has precluded any general survey of the pleuropodia throughout the whole Hexapod group, different investigators have advocated one or the other of these functions, each being guided to his particular view by the special insect to which he devoted his attention. Thus *Graber* has become an advocate of the gill hypothesis from his observations on *Melolontha*, a form in which the pleuropodia are in many ways singularly specialized; *Cholodkovsky*, perhaps impressed by what he supposed to be a facetted surface on the pleuropodia of *Blatta* — in reality a phenomenon due to his use of reagents — believes the pleuropodia to be sense organs; while *Nusbaum* has been most naturally led to regard the modified appendages as glandular organs by his observations on *Meloe*.

I shall proceed to a consideration of the three theories advocated up to date, briefly examining into the reasons which have influenced their adherents, and finally settling on the gland theory as to me the most probable. With this last theory none of the observed facts are in contradiction — while as much cannot be said of the gill and sense organ hypotheses.

A. *The Gill Hypothesis.*

Rathke, the first to find pleuropodia, was also the first to assign to them a function ['44]. Their peripheral position, the delicacy of their surfaces, their close adherence to the egg-membrane, which he thought due perhaps to some sticky substance, and the further fact that they contained cavities filled with what was very probably blood, made *Rathke* believe that he was dealing with respiratory organs. He supposed, moreover, that these organs functioned during embryonic life. The embryos of *Gryllotalpa*, he says, require a great deal of air, on which account they are deposited in spacious subterranean chambers. When simply buried in the earth, the eggs decay.

Ayers followed *Rathke* in his interpretation of the problematic appendages. ['84]. Of late *Graber* ['88] though dealing with these organs at

greater length, and possessing more facts than his predecessors, has adopted their theoretical views without modification. His latest contribution, however, seems to show a tendency to depart from the standpoint held in his paper on polypody, a change of opinion attributable to his study of *Stenobothrus.*

The facts which have led to the assumption of the gill hypothesis are the following:

1. The position of the pleuropodia on the pleuræ near the insertion of the metathoracic legs could not fail to suggest the respiratory organs of the Crustacea.

2. In some insect embryos the pleuropodia are shaped like lamellar gills. This is notably the case in *Melolontha*, the pleuropodia of which are so gill-like that *Graber* figures an Isopod side by side with the insect embryo for the sake of comparison.

3. Blood has been observed to circulate in and out of the pleuropodia.

That these facts are not sufficient to sustain the hypothesis, is shown by the following consideration:

The pleuropodia of *Melolontha* certainly resemble the gills of certain Isopoda, but it is almost equally certain that the appendages of the cock-chafer have departed from the original type of pleuropodium which is best seen in the Orthoptera [*Blatta, Stenobothrus*]. As these organs were present after hatching, in ancestral forms, it follows that in the precursors of *Melolontha*, they might have been balloon-shaped after the animal's escape from the egg. Such large, sack-shaped organs must necessarily become much flattened while they are confined to the narrow space between the body-wall of the embryo and the egg-envelopes.

The cell-layer forming the walls of the pleuropodia in all cases where these organs are not rudimental, is considerably thicker than the ectoderm of the appendages and body walls. Now, as a gill in ultimate analysis is merely a thin layer of cells separating the blood from the air, it becomes very difficult to understand why the comparatively thin layer of ectoderm cells forming the walls of the thoracic and cephalic appendages and the integument in general should not constitute a much more efficient respiratory organ than the thick-walled pleuropodia.

Blood has been seen to circulate in and out of the pleuropodia, but it also circulates in and out of the legs, mandibles, anal stylets, etc., in the same manner.

The bulbous shape of the pleuropodia in the majority of forms is unlike that of any known insect gills. The tracheal gills seen in the larval Ephemeridæ, Odonata, etc., are foliaceous or filamentous; while the protrusile, anal gills of such forms as the larval *Eristalis* are tubular.

Lastly, appendages shaped like the pleuropodia of *Meloe*, *Acilius*, *Zaitha* and *Cicada*, could not have had a respiratory function. The hypothesis is therefore insufficient to cover all the facts and must be either restricted to a few doubtful cases or abandoned altogether.

B. *The Sense-organ Hypothesis.*

Patten ['84] and *Cholodkovsky* ['89] are the only investigators, who have maintained that the pleuropodia of embryo insects may have functioned as sense organs. The following facts make for the probability of this supposition:

1. The pleuropodia are composed of peculiarly modified ectoderm cells.

2. They roughly resemble such sensory structures as the Arthropod eye.

3. Paired sense-organs are known to occur on the abdominal segments of many Arthropods. Cases in point are the curious *Euphausia* with its pairs of eye-like sense-organs and many Orthoptera that have sensory ana stylets.

4. In *Acilius*, as Dr. Patten informs me, the small rods secreted by the pleuropodial cells are comparable to the retinal rods in the larval eye of the same insect. That the secretion in *Cicada* and *Meloe* flows together into one glairy mass, instead of forming bodies of like and definite shape capping the ends of the individual cells may be due to the fact, that the organs are now merely rudimental structures. Dr. Patten tells me that the large lateral sense-organs of the embryo *Limulus polyphemus* produce a glairy secretion very similar to what I have described in *Cicada* ['89 a and b].

5. The pleuropodia are similar in shape and manner of development to the halteres of the Diptera and the pectinate appendages on the second abdominal segment of Scorpions, both of which modified appendages, as we have good evidence for believing, are functional sense-organs.

These facts are weighty. It seems to me, however, that the supposition that the pleuropodia are sense-organs, is untenable, for the reason that no investigator has yet observed even a trace of nervous tissue in connection with the pleuropodial cells. In sense-organs as large as the pleuropodia we should certainly expect to find a well-developed neural element, since in the case of much smaller and more insignificant sense-organs it is not difficult to detect the nervous connection. Granting that the pleuropodia are rudimental structures, it remains none the less improbable that a nervous connection, which in so large an organ must have been prominently developed at one time, could have disappeared so completely while the sensory cells themselves underwent comparatively little diminution in size. The pleuropodia are, moreover, most conveniently located for innervation from the large ganglion of the first abdominal segment or from one of its main branches.

It is, of course, possible, that in some or all forms the organs under consideration may have had a sensory function; but the facts accumulated up to the present, do not permit us to assign to the cells any other than a secretory function.

C. *The Gland Hypothesis.*

Besides *Patten*, who claimed that the pleuropodia might be glands ['84] no one till very recently has considered this view. In the July number of the American Naturalist ['89a] I advocated this view in a brief note.* In one of the August numbers of the "Biologisches Centralblatt" ['89] *Graber* published his remarks on the pleuropodia of *Stenobothrus*, attributing to these organs a glandular function. In one of the September numbers of the "Zoologischer Anzeiger" ['89b] a preliminary account of my observations on the pleuropodia of *Zaitha* and *Cicada* was published. In one of the October numbers of the "Biologisches Centralblatt" appeared *J. Nusbaum's* description of the pleuropodia of *Meloe* ['89]. *Nusbaum* regards these organs as glandular, but terminates his paper in a confusion of ideas as evinced by the following remark: "Die druesige Natur der Bauchanhænge bei den genannten Insekten [*Meloe*, *Stenobothrus*] [die ohne Zweifel auch bei anderen gefunden werden wird] spricht dafuer, dass wir es hier wahrscheinlich mit rudimentaeren Organen, die nicht bloss zur gewoehnlichen Gangfunktion bei den Insektenvorfahren, sondern vielleicht auch noch zur Atmungsfunktion dienten, zu thun haben."

I fail to comprehend how the glandular nature of the pleuropodia can in any way suggest that they may have functioned simultaneously as ambulatory and respiratory organs.

The following are my reasons for assigning a glandular function to the pleuropodia:

1. The entire ectoderm of Arthropods, excepting its nervous derivatives, is essentially a glandular layer, one of its prime functions being the secretion of the chitinous armour so characteristic of these animals. This function is retained by the ectoderm cells, even when they are pushed into the body as in the case of the tracheae, tentorium, œsophagus and rectum. Looking at the compound Arthropod eye from *Watase's* standpoint ['89], as a cluster of ectodermic invaginations we have a case where ectodermic cells still retain their chitin-secreting habits though pushed below the surface of the general integument and covered by superjacent cells.

2. The pleuropodial cells closely resemble other simple ductless glands in insects, such as the wax-glands of the Aphididæ and the stinging glands of some Lepidopterous larvæ. In the embryo and young larvæ of the Bombycid *Hyperchiria io*, I have observed the formation of the huge branching spines, which arranged in several parallel rows, repel the insects enemies with their stinging secretion. The immensely enlarged ectoderm cells which secrete the poison in the lacunæ of the spines, have very glandular cytoplasm and large nuclei, thus resembling the pleuropodial cells of *Blatta*.

3. The pleuropodial cells in several insect embryos produce a secretion, the character of which differs considerably in different forms.

* This number of the Naturalist did not appear till Nov. 18th, 1889.

4. In some insects at least [*Blatta*, *Periplaneta*, *Xiphidium*, *Stenobothrus*] the chitinous cuticle does not cover the pleuropodia, even after investing the body of the embryo. On the supposition that we are dealing with ductless glandular organs, the reason for this is obvious. The secretions of cutaneous glands cannot penetrate a thick and unmodified layer of chitin, so we find gland cells covered with a cuticle the [chemical?] structure of which departs from that of ordinary chitin. This cuticle is also thinner than that secreted by the unmodified hypodermis cells of the general integument. A good example of such attenuation and modification in the molecular structure of the cuticle covering ductless cutaneous glands is furnished by the collophore of *Anurida maritima* described below. Now the first cuticle shed by the embryo in the egg must be regarded as the attenuated rudiment of what was formerly a much thicker cuticle shed by the insect in some post embryonic stage of existence. Supposing that the cuticle originally covered the pleuropodia of such an ancient insect had been more delicate than that covering the remainder of the body, it would cease to be secreted in the embryos of existing insects because reduced to such excessive tenuity. There is still another possibility which might account for our not finding a chitinous cuticle on the pleurodia: the secretion of these organs may itself be some chemical modification of the chitin, which covered the appendages before the peculiar differentiation of their cells set in.

5. The lack of any apparent innervation to the pleuropodia, though adducible as a fact against the sensory nature of the organs, is just what we should expect on the supposition that they are glandular. The difficulties encountered by histologists in tracing the innervation of glands is well known.

6. The manner in which some pleuropodia degenerate suggests what is known to take place in many glands that indicate their relation to epithelial structures by secreting their own broken-down cells. The milk glands of the mammalia and other cases will suggest themselves to the reader.

7. The structure of the pleuropodia described up to the present, though considerably diversified, is in all cases consistent with a glandular function.

Having reached the conclusion that the pleuropodia functioned as glands in ancestral insects, I have probably made the utmost use of the few facts at my disposal. The word "gland," however, is so indefinite, since the special functions of glands are so numerous, that, stopping at this point, the hypothesis is still very vague. For the sake of giving it clearer outlines, I will elaborate still further, though aware of the dangers I incur in descending to particulars.

What then was the special glandular function of the pleuropodia in primitive insects? In seeking an answer to this difficult question we are pursuing the most logical course when we muster the different classes of glands observed in air-breathing Arthropods, and select for special consideration the class that presents the greatest variation in structure and the widest dis-

tribution. On making this review we find in the first rank the odoriferous glands. These function either as means of defense or as aphrodisiacs, or probably in many species as both. The great importance of copulation and protection from enemies readily explains why the odoriferous glands should play so prepollent a role in the lives of Arthropods and even higher animals. I will give a brief though by no means exhaustive list of forms possessing odoriferous glands, for the sake of showing the wide distribution of these organs among the different groups of air-breathing Arthropods and the variety of their structure and secretions.

According to *Marx* ['86] the Pedipalp *Thelyphonus* emits a secretion which smells like acetic acid. The Myriopod *Fontaria gracilis* secretes from its series of repugnatory glands a fluid which contains free hydrocyanic acid [*Claus*, '87]. I have frequently seen our common *Julus* [*Spirobolus*] *marginatus*, when irritated emit from its repugnatory glands a brown liquid with a pungent odor not unlike bromine, though this element very probably does not enter into its chemical composition.

Among the Orthoptera numerous cases might be adduced. *Minchin* ['88] lately discovered in *Periplaneta orientalis* a new gland, which "consists of two pouch-like invaginations lying close on each side of the middle line, between the fifth and sixth terga of the dorsal surface of the abdomen." These pouches "are lined by a continuation of the chitinous cuticle, which forms within the pouches numerous stiff, branched, finely pointed hairs, beneath which, i. e., on the side towards the body cavity, are numerous glandular epithelial cells." *Minchin's* supposition that these organs are odoriforous glands has been proved to be correct by *Haase* ['89]. "Drueckt man naemlich das Abdomen einer Kuechenschabe derart, dass die Leibeshoehlenfluessigkeit nach hinten gedraengt wird, so treten zwischen dem 5 und 6. Hinterleibessegment vor den harten Rueckenplatten des letzteren zwei kleine, durch das eindringende Blut gelblich durchscheinende Saeckchen hervor und verbreiten sofort ganz intensiv den bekannten Schabengestank. Dass dieser seine Quelle in den beiden Stinkdruesen hat, wird durch vorsichtige Ausloesung der letzteren leicht nachgewiesen." Similar eversible stink-glands have been observed in the Blattid *Corydia* by *Gerstaecker* ['61] and *Haase* ['89].

An American Phasmid, *Anisomorpha buprestoides*, has well developed repugnatory glands, which have been alluded to by *Say* ('59, Vol. I, p. 84) and other writers. I quote from *Maynard* ('89) who has published the latest account: "The devil's horses, as they are called by the negroes, were in pairs, the females being evidently about to deposit their eggs. I usually found them lying quietly in a fold of the saw-palmetto, with the legs close to the body and the antennae together and pointing straight forward while the comparatively diminutive male, which is never more than a third as large as the female lay close beside his mate, always clinging to her whenever she moved and was thus carried by her. Both were very sluggish, not moving until actually touched, then the female raised herself

slowly on her hind legs and straightway there emerged two streams of a vaporous fluid from the upper angle of the thorax near the neck. These streams were directed forward, but at a slight angle outwardly and upward, that is when the insect was resting on a horizontal surface. When the matter discharged first leaves the orifice from which it is expelled, it is a milky fluid, but as it is apparently as volatile as ether, it almost instantly assumes the form of vapor and is projected at least six inches. This fluid has a most peculiar pungent or peppery odor and although the moisture from it dries away very quickly from any object with which it comes in contact, the odor is retained for a long time. The fluid when thrown against the hand has no perceptible effect on the skin, but I have been told repeatedly by the negroes that the effect upon the eyes is very painful."

Odoriferous organs are well developed in the Hemiptera. Everybody is familiar with the secretions emitted from the metathoracic pear-shaped glands, the duct of which opens by means of the osteoles between the hind legs.

The Neuropteran lace-wings (*Chrysopa*) are characterized by a powerful and very unpleasant odor.

Passing to the Coleoptera, many Carabidæ, that produce from their anal glands secretions containing formic and butyric acid might be mentioned. Every collector of our native Coleoptera must have noticed the very powerful secretion produced by our common *Chlaenius sericeus* when captured. The bombardier-beetles [*Brachynus*], are well known for their habit of emitting clouds of pungent secretion accompanied by decrepitation. *Loman* ['87] has recently asserted that the gaseus secretion of the anal glands of the Paussid *Cerapterus 4- maculatus* contains free iodine. Among Cerambycids the European *Aromia moschata* has a powerful musky odor and the allied *Callichroma plicatum*, emits a strong honey-like smell according to the statement of my friend Mr. F. Rauterberg, who has collected numbers of these beautiful insects in Texas. The members of the genus *Meloe* exude oily drops of cantharadin from the joints of their legs when disturbed. The *Coccinellæ* have a similar habit of exuding a deep yellow liquid. The Tenebrionidæ are usually supplied with some unpleasant secretion.

Odoriferous glands occurs both in larval and imaginal Lepidoptera. *Fritz Mueller* has studied the scent glands [Duftflecken] on the wings of numerous South American Lepidoptera ('86 a — e). The forked protrusile gland of *Papilio* larvae and the pungent odor which it diffuses is well known. Its structure has been described by *Klemensiewicz* ['82]. One of our common species of *Pieris* has redolent wings. According to *Maynard* ['89] the exquisite little Bombycid *Utetheisa bella* "exudes an orange colored fluid from its thorax that has an unpleasant odor." According to Packard the larva of *Lochmœus tessella*, Pack, when disturbed sends out from each side of the body a shower, or spray of clear liquid. "The opening of the gland is in the lower anterior part of the prothoracic segment". *Poulton*

['86] has described the formic acid secretion ejected from the prothorax of *Dicranura vinula*. According to the same observer *Dicranura furcata* everts from the same region of the prothorax a gland "consisting of six diverging processes of a light green color, divided into two groups of three each." He also mentions an eversible gland in the prothorax of the larvæ of *Melitaea artemis* and *Catocala* species.

Peculiar scent organs, resembling those of the larval *Papilio* and consisting of a pair of tentaculiform processes, eversible from between the seventh and eighth ventral segments of the male imagines, have been described by *Smith* ('86) for the Bombycids *Leucarctia acræa* and *Pyrrharctia isabella*. These processes, which are orange colored and fully half an inch long in *Leucarctia*, but whitish and somewhat shorter in *Pyrrharctia* are covered with hairs, blackish in the former and snow white in the latter species. "In both species an intense odor, somewhat like the smell of laudanum, is apparent when first the tentacles are exposed; and there is no reasonable doubt but that they are odor-glands, though exactly what purpose they serve is not so clear." *Smith* says that a Mr. Morgan has described these organs in *L. acræa* and similar structures in *Agrotis plecta* and *Euplexia lucipara;* and that similar organs have been described for *Aletia xylina* by *Riley*.

Among the Diptera prominent cases are rare. *Coenomyia ferruginea* emits an odor which reminds me of the juice of a certain species of *Hypericum*, and which has often enabled me to detect the presence of the insect in the woods when several feet distant. The odor is retained in dried insects that have preserved for years in collections. The species of *Gastrophilus* have a sharp, disagreeable smell, powerful in some species, faint, but still perceptible in others. (*Leunis* '86, vol. II. p. 419.)

Among the Hymenoptera the formic acid secretions of the ants are well known. The catapillar-like larvæ of the species of *Cimbex*, both European and American, when irritated secrete a pungent green liquid from pores arranged along the sides of the body.

The cases cited are but a few of the many that will occur to every field entomologist. The histological structure of the glands, so different in different forms, has not been considered, as it would lead me beyond the confines of my subject. On *a priori* grounds we should expect to find that structures so useful to their possessors as the odorifferous glands are to insects, have been profoundly modified by the action of natural selection. Their wide occurrence in insects of all orders shows, moreover, that they have been in use for a great length of time. The *Archentoma* probably lived in damp places like those inhabited by the living species of *Peripatus*, *Myriopoda*, *Thysanura* and *Blattidae* and, being of a harmless nature like their modern descendants, might have made considerable use of large odoriferous glands on the pleurae.

If I am correct in my supposition that the pleuropodia functured in the *Archentoma* as odoriferous organs, they must be regarded as much less per-

fect structures than their modern equivalents, such as, for instance, the anal glands of the *Carabidae* and the analogous metathoracic organs of the Hemiptera.

Of the three types of pleuropodia, which I have distinguished, the evaginate bulbiform, calyculate, and invaginate, each had its advantages and disadvantages, as a secretory organ. The evaginate bulbiform pleuropodium presents extensive secreting surface but from its prominence and necessarily delicate covering it would be readily injured. Situated on the abdomen in the median ventral line, or in line with the metathoracic legs such organs would, if prominent, be rubbed against the ground or interfere with the movements of the hind legs. This is probably why the pleuropodia move towards the pleurae and project from points outside of and near the insertion of the metathoracic legs. This position is also most advantageous for repugnatory organs.

The calyculate type, being a transition from the bulbiform to the invaginate types, has the tips of the secreting cells protected. The secretion may accumulate in the cavity of the organ and be expelled to more advantage when the animal is irritated. The projection of the organ beyond the general surface of the body, however, renders it subject to the same injuries as organs of the bulbiform evaginate type.

The advantages and disadvantages of the pleuropodia of the invaginate type are obvious. The glandular cells are efficiently projected, but in *Zaitha* and *Cicada* the secreting surface of the cells is much reduced. Were these glands hollow we should have much more efficient organs, resembling the stinkglands of *Julus*. It is probable that such hollow invaginated pleuropodia will yet be discovered in some insect embryos. (Hemiptera?)

In the best examples of modern odoriferous glands, like the anal glands of the Carabidae, where all the delicate secreting cells are protected by being pushed into the body cavity, their being tubular or racemose greatly increases the amount of secreting surface, while the presence of a reservoir renders it easy for the insect to dispose of a great amount of its malodorous secretion at a moment's notice. Forms like the larval *Papilio* with its eversible prothoracic gland have all the advantages possessed by the bulbiform pleuropodia with none of the disadvantages, since the delicate organ can be drawn back into the integment out of the reach of injury.

The little inefficiencies exhibited by all the pleuropodia as odoriferous glands when compared with the more perfect of their modern analogues, probably explain why the latter have usurped their places. The pleuropodia would, on this supposition, furnish an excellent example of a set of organs that have gone down in the struggle for existence and have been replaced by organs of more perfect structure though of the same general function.

It is interesting in this connection to cast a glance at *Scudder's* tables illustrating the sequence and relative importance of the different orders of

insects during geological time, ['86, p. 110 to 118].' *Scudder's* group of *Palaeodictyoptera* extends from the Silurian to the Trias, culminating in the Carboniferous and Permian. This group comprises the generalized precursors of the more modern Orthoptera, Hemiptera, Neuroptera, and Coleoptera. It seems not unlikely that some or all of these ancient forms may have possessed pleuropodia throughout life, and that specimens may yet be found perfect enough to show these organs in the adult. The Orthoptera, Neuroptera and Coleoptera proper appear in the Trias,* while the Hemiptera are comparatively well represented in the Lias. Now these more ancient orders, constituting the division Heterometabola (of Packard), are just the ones, as will be seen from a glance at my table, whose embryos possess pleuropodia. The Diptera, and Hymenoptera, occurring in the Lias, and the Lepidoptera, appearing in the Oolite, have to all appearances kept increasing in number and variety up to the present time. In the embryos of insects of these orders, comprising the Metabola of Packard, no pleuropodia have been observed up to date.

D. *Homologues of the Pleuropodia in the Lower Tracheata.*

A consideration of the pleuropodia of insects embryos would be incomplete without a search for their homologues among the lower Tracheata, where there are numerous forms with abdominal appendages more or less clearly developed. Organs of more or less interest in connection with the pleuropodia of insects occur in scorpions, Solifugæ, spider embryos, Symphyla and Thysanura. These cases I will consider in order.

Cholodkovsky ['89] has called attention to the "combs" of scorpions in connection with the pleuropodia of *Blatta*. These organs, according to all accounts, develop as a pair of appendages on the second abdominal segment and function throughout postembryonic life as sense organs. They cannot be regarded as the homologues of the pleuropodia, since there is no ground for maintaining a homology between the second abdominal segment of the Arthrogastera and the first abdominal segment of the Hexapoda.

Another case of a somewhat similar nature has been made known by *Croneberg* ['87] in *Galeodes araneoides*. In the just hatched embryo of this Solpugid, there is a pair of flat wing shaped appendages about 0.5 mm long on the cephalothorax intercalated between the first and second pairs of legs. Their insertions are more pleural than those of the ambulatory appendages. Like the pleuropodia of insects, they are pedunculated sacks consisting of a single layer of ectoderm cells and contain neither tracheae, muscles nor nerves. No traces of these peculiar organs are to be found in the adult *Galeodes*. It seems to me very doubtful whether these organs

* Since the publication of Scudder's work alluded to, undoubted remains of Coleoptera have been found in the Coal Measures of Silisia.

are to be regarded as modified cephalothoracic appendages and not rather as outgrowths of the pleural wall out of line with the legs. The isolated fact, though interesting, can be of little service, till reinforced by more observations. Of course no homology can be maintained between these wing-like organs and the pleuropodia of insect embryos.

In spider embryos the knob-shaped appendages on the four basal abdominal segments are very distinctly defined. They have been described by *Balfour* ['80], *Locy* ['86], *Bruce* ['87] and *Morin* ['87]. There can be no doubt, from the manner in which they arise, that these knob-shaped appendages are the serial homologues of the cephalothoracic appendages, but so vague is our knowledge of the segmental homologies between the Arachnida and Hexapoda, that it is impossible to say which of the four pairs of appendages corresponds to the pleuropodia.

Bruce ['87], maintains that in spiders "probably two abdominal appendages are invaginated to form each lung-book." According to *Morin* ['87] the first pair of knob-shaped appendages become the covers of the lungs which invaginate at their bases; the second pair disappear completely, while the third and fourth pairs form the spinnerets, the ectoderm on the summit of each of the four protuberances invaginating to form the spinning glands. Barring the question of homology, the observations on the pleuropodia of *Cicada* and *Zaitha*, given in the first part of this paper, make it easy to see how an appendage might invaginate to form a lung-book, as maintained by *Bruce*.

As soon as we reach the Symphyla and Thysanura, we no longer encounter any difficulty in settling on the true homologue of the first abdominal segment of insects.

The remarkable synthetic form, *Scolopendrella*, has twelve pairs of legs. *Ryder* ['81], *Packard* ['81] and *Haase* ['87], agree that the first three pairs are to be regarded as the homologues of the three pairs of legs of the insecta and that the three segments to which they belong, are to be regarded as the homologues of the pro-, meso-and metathoracic segments respectively. If this view be correct, and there is certainly nothing to militate against it, then we may regard the fourth postcephalic segment of *Scolopendrella* as the homologue of the first abdominal segment of insects. This being the case, the two ambulatory legs attached to this segment in the Symphyla are the homologues of the pleuropodia of embryo Hexapods.

From the *Symphyla* we pass to the *Thysanura*, a group comprising several forms of interest in connection with the pleuropodia of embryo insects. Appendages are known to occur on the basal abdominal segment in *Campodea*, *Machilis* and allied species, and in the *Collembola*. Throughout the Thysanuran group the basal abdominal segment is doubtless to be regarded as truly homologous with the first abdominal segment of the higher, or winged Hexapoda (Pterygogenea). Hence, a pair of appendages arising on this segment in the Thysanura as ectodermic evaginations, with mesodermic cores, in line with and at approximately the same time as the

thoracic appendages, is to be considered as truly homologous with the pleuropodia of embryo insects.

It has long been known that species of *Campodea* bear on the first abdominal segment a pair of two-jointed appendages homostichous with the meta-thoracic legs. No such appendages appear on any of the other abdominal segments; a fact which would seem to indicate that they either still subserve some particular function or are the rudiments of once functional organs differentiated from a pair of probably ambulatory appendages. As I have been unable to obtain specimens of *Campodea* for study, and can find no record in the literature to which I have access of any observations made from sections of this pair of curious appendages, I cannot decide which of these conjectures is the more probable. Be this, however, as it may, *Campodea* is to be regarded as a form, which, so far as its appendages are concerned, remains throughout life in a stage corresponding with the Orthopteran or Coleopteran embryo just after revolution.

The second to seventh abdominal segments of *Campodea* present each a pair of small unsegmented styliform appendages. These contrast in size and shape with the pair of appendages on the basal segment. In *Japyx* the differentiated basal abdominal appendages of *Campodea* are replaced by styliform appendages, pairs of which also occur on the second to seventh segments. In *Nicoletia* and *Machilis* styliform appendages occur on the second to ninth abdominal segments. *Machilis* also presents similar processes on the coxal insertions of the meso-and metathoracic legs. The number of these style-like organs varies in different species of *Lepismina*. In *Lepisma saccharina* such appendages occur only on the eighth and ninth abdominal segments. *Oudemanus* ['89] has found them on the seventh to ninth abdominal segments of *Thermophila furnorum*.

These paired styliform processes are not regarded by *Haase* as homologous with the true abdominal appendages of the Symphyla and Myriopoda, but as homologous with the coxal spurs of the lower Tracheata. He consequently maintains that the real appendages to which they belonged have disappeared on all the abdominal segments of *Machilis* and its allies and on all except the first abdominal segment of *Campodea*. *Haase* supports this view with the following facts. In their structure, the styliform appendages resemble very closely the spines and spurs so common on the body and legs of the Tracheata. They are unsegmented and unlike true appendages contain no muscular core. They correspond in structure, and in their method of insertion with the coxal spurs of Myriopods, *Scolopendrella*, Thysanura and certain *Blattæ* [notably South American Blaberidæ]. *Haase*, who seems to have given very careful attention to this subject, is very probably correct in his conclusions in regard to these styliform appendages, or "pseudozampe," as they are called by *Grassi;* still the proof cannot be regarded as complete till their early development has been studied.

Though the appendages under consideration contain no muscular tissue

when fully developed, it is, of course, possible that they may have contained evaginations of the mesodermic somites during the first stages of their development. We have a case in point in the pleuropodia of insect embryos. In the younger stages, as I have shown in *Blatta*, each of the two mesodermic somites of the first abdominal segment sends a papillar process into an evaginating pleuropodium in exactly the same manner as the mesodermic somites of the thorax send processes into the legs. Subsequently, when the pleuropodia have become distinctly differentiated, the mesodermic elements, which in the thoracic appendages persist and are converted into muscles, are pushed back into the body cavity. Using *Haase's* criterion and considering only the mature appendages, we should not be justified in regarding the pleuropodia as true appendages.

The evidence in regard to the origin of the styliform appendages, which *Haase* has failed to give us, is at least in part supplied by *Oudemanns* ['87.] The Dutch investigator observed that of the three pairs of styliform processes occurring on the 7th, 8th and 9th abdominal segments in both sexes of *Thermophila furnorum*, only one pair, and that the hindmost, was to be found in the youngest specimens examined. Next in order of time appears the pair on the eighth and finally the pair on the seventh abdominal segment. This manner of making their appearance, as *Oudemanns* suggests, is strong evidence against their being true appendages. It may also be noted in this connection that the styliform appendages even in those forms that possess many pairs are longest on the posterior segments and gradually diminish in length anteriorily. This is contrary to what we expect in true appendages; for these in insect embryos usually decrease in distinctness and prominence in the opposite direction.

In the Collembola a peculiar organ, called by *Packard* the collophore, occurs in the median ventral line of the first abdominal segment. This organ is thus described by *Lubbock* ('73, p. 68):

"Underneath the anterior abdominal segment is the ventral tube, or sucker. In *Podura*, *Lipura*, and the allied genera, this organ is a simple tubercle, divided into two halves by a central slit; in other genera, as, for instance, in *Orchesella* and *Tomocerus*, the tubercle is enlarged, and becomes a tube divided at the free end into two lobes. In the *Smynthuridae* and *Papiriidae* the organ receives a still further and very remarkable development; from the end of the tube the animal can project two long, delicate tubes, provided at their extremity with numerous glands."

Lubbock makes the following remarks on the function of the collophore:

"No one, indeed, who has watched the habits of the Collembola, can doubt its function. If a *Smynthurus* is laid on its back — a position from which it has some difficulty in recovering its feet — and if, while it is in this attitude, a piece of glass is brought within its reach, the animal will endeavor to seize it with the feet, but at the same time it will project one or both of the ventral tentacles and apply it, or them, firmly to the glass,

emitting at the same time a drop of fluid, which, no doubt, gives a better hold. In the parallel case of the *Poduridae*, M. l' Abbé Bourlet supposes that the ventral tube act as follows: "1° qu' il sert à ces insectes à se maintenir sur les surfaces perpendiculaires en y faisant le vide; 2° que le liquide excrété par lui sert à humecter la queue et la rainure; 3° qu' il supplée à la faiblesse des pattes dans les chutes qui suivent les sauts." I am, therefore, disposed to agree with him in so far as he denies that the adhesive power depends altogether on the viscous fluid; but, on the other hand, I cannot attach much importance to his two latter suggestions. De Geer well understood the use of this curious organ. He says: "Quand la Podure [under which name he includes the present genus *Smynthurus*] marchait contre les parois du poudrier, il lui arrivait souvent de glisser; c' était comme si les pieds lui manquaient, de façon qu' elle était sur le point de tomber; dans l' instant même, les deux filets parurent et furent lancés avec rapidité hors de leur étui, s' attachant dans le moment au verre par la matière gluante dont ils sont enduits, en sorte qu' alors la Podure se trouvait comme suspendue a ces deux filets." Nicolet gives a similar explanation of their function, and, like De Geer, attributes the adhesiveness to the glutinous matter which they secrete."

The question has presented itself to me: Is not the collophore developed from a pair of true appendages united in the median ventral line, though serially corresponding with the thoracic legs and hence truly homologous with the pleuropodia of insect embryos? Although I have been unable to give the subject the careful study which it deserves, I believe that I have unearthed a few facts calculated to answer the question in the affirmative.

The only embryological observations made up to date on the origin of the collophore are recorded in *Ryder's* brief account of the development of *Anurida maritima* ['86]. His figures [Figs. 6, 9 and 10, plate 15] show clearly that the collophore consists of a pair of true appendages applied to each other in the median ventral line, even if he had not expressly stated that "during the earlier stages the limbs, antennæ, collophore, etc., had the form of mere blunt, paired papillæ, or of blunt, clavate, tentacle-like paired outgrowths from the lateral surfaces of the ventral plate or elongated germinal area."

I can supplement this embryological evidence by a few observations on the collophore of *Anurida maritima*. This maritime species was found in great numbers clinging to the under surfaces of stones between tides at Woods Holl, Mass. Its collophore is less complicated than that of our common inland forms, and therefore better calculated to give a correct idea of the fundamental pattern underlying its structure. Specimens were killed by being placed for a minute in Carnoy's fluid heated almost to boiling and were then preserved in 80 per cent. alcohol.

The collophore is quite prominent in surface view (Fig. 16 *c*.) appearing as a heart shaped tubercle on the middle of the ventral face of the basal abdominal segment. The lateral edges are raised to form distinct rims,

crowned with a few feeble hairs. The portion included between the lateral rims is flat and of a much paler color than the remainder of the integument, which is provided with an abundance of blue pigment. A very distinct slit divides the organ into two symmetrical halves. This is all that can be seen from the surface; for further details recourse must be had to cross sections. (Fig. 15.) Here it is seen that the projection of the organ above the general surface of the segment is about equal to its diameter. The cuticle (*ct.*) is rather thick and externally very finely papillose. This unevenness of surface is continued over the lateral rims, but where the center is depressed and paler the papillose cuticle is replaced by a smooth and more delicate layer (*ct.*), which stains pink in lithium carmine. This portion of the cuticle, deeply induplicated at the median slit that divides the organ into two symmetrical halves, evidently differs considerably in its chemical structure from the unstainable papillose cuticle covering the remainder of the body. The hypodermis forming the sides of the collophore has very large flattened nuclei (*hy.*), which are almost concealed in the dense layer of pigment. Beneath it lies a mass of connective tissue (*cn*). At the inner boundary of the rim of the ventral face of the organ, where the papillose cuticle is replaced by the delicate and stainable layer, the hypodermis also undergoes a marked change. From being a rather thin, deeply pigmented layer with huge flattened nuclei it becomes a thicker layer of evenly granular, unpigmented protoplasm, smooth on its external face but raised into numerous rounded protuberances on its inner surface. (*gl.*) A spherical nucleus considerably smaller than those of the pigmented hypodermis, is lodged in each of these protuberances, which thus represent the different cells. These are not, however, separated by perceptible boundary lines; hence this modified portion of the hypodermis, and perhaps also the unmodified portion, is to be regarded as a syncytium. The whole of the hypodermis underlying the modified cuticle is peculiarly and symmetrically folded. In its center it presents a broad induplication corresponding with the narrower one of the superjacent cuticle. The cells forming this median portion are small and flat. On either side there is another rather deep infolding, to the inner angle of which a delicate muscle is attached. (*ms.*) The ventral nerve chain, indicated at *n*, runs beneath the median induplication. As may be seen from the figure, there is a wide space between the modified hypodermis and its cuticle. I have seen no traces of blood in this cavity, which in some specimens contains small masses of a granular and very deeply stainable secretion. (*s.*) Larger masses of the same substance are frequently seen clinging to the outer surface of the modified cuticle. I regard the modified hypodermis as the gland that secretes this granular substance. The cavity of the organ bounded on the outside by the hypodermis is filled with blood (*bl.*) which, when the organ is called into action, is probably forced against the glandular hypodermis, the two retractor muscles relaxing. Probably the infolding of the cuticle is pushed out simultaneously with the three infoldings

of the glandular hypodermis. The great extent of surface of the hypodermis compared with that of its cuticle may indicate that during protrusion the latter is stretched and attenuated, thus allowing the secretion of the glandular cells to transude more readily.

I have made no observations on the use to which the organ is put by the living animal. The observations of *Lubbock* and *De Geer* quoted above, render it probable that *Anurida maritima* uses its collophore as a sucker wherewith to fasten itself to the surface of the stone while the water is rising and falling. It probably does not leave its place of concealment during high tide to move about on the surface of the water like some of our inland species. As its body, like that of most other species, is not readily wetted, the layer of air that would cover it when emersed might be sufficient for respiration till the returning ebb.

The collophore of *Anurida*, may be readily reduced to a pair of appendages applied to each other in the median ventral line. The median induplication of the hypodermis and the corresponding single infolding of the cuticle I take to represent all that remains of the originally wide sternal area separating the two appendages. Sections through the more complicated collophores of a few of our common Podurids have convinced me that these organs are also reducible to the simple pattern of a pair of appendages more or less closely united in the median line. I have not, however, made a sufficiently extended study of the more complicated types to be able to explain the manner in which their different parts originated. It is to be hoped that some investigator will in the near future subject these interesting organs to a rigid comparative examination, from both an anatomical and physiological standpoint. *Ryder's* observations on the embryos of *Anurida maritima*, together with the observations I have presented on the adult of the same species, render it very probable that the Collembolan collophore is to be regarded as a pair of appendages homologous with the pleuropodia of the heterometabolous insects.

It seems, moreover, not improbable that the collophore of the Collembola may have been derived directly from the pleuropodia of primitive insects. Originally a pair of protuberances, covered with a sticky, perhaps malodorous secretion, these appendages may have come to be of assistance as adhesive organs in such leaping species as had rather weak limbs and lived where they found it of advantage to alight on surfaces of different inclinations.

Milwaukee, December 20th, 1889.

While my manuscript was being copied for the printer, *E. Haase's* recent paper entitled "Die Abdominalanhänge der Insekten, mit Berücksichtigung der Myriopoden" (Morph. Jahrb. Bd XV 3. Heft. p. 331–435, 1889) came to my notice. This treatise, by far the most complete and accurate ever published on the subject, contains, besides a mass of other observations, so many interesting facts and considerations bearing on what has been set forth in my more special contribution, that I seize the opportunity to append a few paragraphs on the points of most importance in connection with the pleuropodia of insect embryos.

Haase has made a study of the pair of appendages on the first abdominal segment of *Campodea staphylinus* and finds that they are specialized to form glandular organs (p. 378–380). These two-jointed appendages do not stand off at right angles to the body but are applied to its surface. The inner face of the broadly oval distal joint, i. e., the face turned to the ventral surface of the abdomen is beset with 20–30 peculiar hairs (Haaranhänge) arranged in rows. The two outer rows are composed of longer and thicker setæ, arranged like the teeth of a comb. Each bristle is inserted on a rounded follicle (Balg) which is surrounded by a ridge. A gland-cell terminates in each follicle. This pair of appendages is regarded by *Haase* as "rudimentäre, in der Entwicklung zurückgebliebene Beine," and hence as in no sense homologous with the ventral stylets (Ventralgriffel) occurring on the 2nd to 7th abdominal segments. As evidence in favor of this view he adduces the fact that the appendages of the first abdominal segment are largest in young *Campodeæ* and that their relative size diminishes with the growth of the insect.

Haase makes a somewhat similar observation on *Iapyx gigas* and *solifugus*. In these Thysanurans no appendages are developed on the first abdominal segment, but in their stead six peculiar glands which are described as follows:

"Bei *Japyx gigas* Brauer aus Cypern, einer Art von 23–26 mm Länge, tritt an der ganzen Bauchplatte des ersten Abdominalsegmentes jederseits des schmalen, etwas eingesenkten Mittelschildes eine flache Vorwölbung der Seitentheile auf. Am Hinterrande liegen jederseits des nur 0,125 mm breiten mittelsten Stückes, das eine einfache dünne Duplikatur der Ventralhaut darstellt, drei scharfbegrenzte, von einer bindegewebigen Membran umschlossene Drüsenzellmassen, welche selbst in zurückgezogenem Zustande den Plattenrand noch überragen und von einer schmalen Ringfalte eingeschlossen sind. Die äusserste Drüsenmasse ist bei 0,25 mm Länge 0,135 mm hoch und an den Vorderecken abgerundet. Die mittlere bildet einen eher abgerundet rechteckigen Körper von 0,13 mm Länge und 0,13 mm Höhe; die innerste ist flach und quer gestreckt, 0.26 mm lang und nur 0,09 mm hoch. Die beiden äusseren Drüsenmassen sind an ihrer freien Hinterfläche sehr dicht, die innerste spärlicher mit starren, spitzen, gelben Börstchen besetzt, die bis 0,03 mm lang werden und deren

an der mittleren Masse gegen 100, an der äussersten über 200 vorkommen. Die Drüsenzellen sind trübe durchsheinend, von gelblicher Farbe."

"Der Bau der Drüsenmassen am ersten Hinterleibsringe von *J. gigas* wurde an Längschnitten untersucht. Die auf der Cuticula stehenden Härchen sind gelblich und bis zur Spitze von einem weiten Kanal durchzogen, der scheinbar direkt in den langen Hals einer einzelligen Drüsenzelle übergeht. Die Ausführgänge sind in der Mitte oft stark aufgeblasen, während sie sich am Ende wieder bis zu 0,001 mm Durchmesser verschmälern.

Aehnlich lässt sich auch bei *J. solifugus* der Uebergang des die hohlen kurzen Haarstacheln durchziehenden Kanals in den dünnen 0,02—0,03 mm langen Ausführungsgang einzelliger rundlicher Hautdrüsen von 0,005—0,008 mm Durchmesser erkennen."

These observations on *Campodea* and *Japyx* are of considerable interest in connection with the hypothesis advanced in the concluding paragraphs of my paper. Notwithstanding the glandular portion of the first abdominal segment in *Japyx* is broken into six clearly defined masses, it may still be true that originally the three glands on either side of the median sternal line formed only one mass. The pair of glands which might thus have given rise to the six separate masses mav be traced back through structures like the pleuropodia of *Cicada* to a pair of true glandular appendages like those on the first abdominal segment of *Campodea*. *Haase's* Fig. 17, Plate XV, representing a section through the glandular mass in *Japyx*, calls to mind the pleuropodium of *Zaitha*.

Haase also gives a very interesting account of the eversible sacks, which have long been known to occur in pairs on the ventral faces of the abdominal segments in many Thysanura. He has subjected both literature and insects to a painstaking examination, with results that I here very briefly summarize: In the Myriopod *Lysiopetalum* (two species) pairs of eversible sacks occur on the coxæ of the 3rd-16th pairs of legs; in *Polyzonium germanicum* and a Moluccan *Siphonophora* there is a pair of these sacks on nearly every segment caudad from the third. *Scolopendrella* has 10 pairs of eversible sacks, a pair on each segment from the 3d to the 12th. In *Campodea* they are present on the 2nd to 7th abdominal segments; in *Japyx* on the 2nd abdominal segment. In *Machilis maritima* and *M. polypoda* pairs of eversible sacks occur on the 1st to 7th abdominal segments; one large pair on the first and two smaller pairs on each segment from the 2nd to the 5th; the 6th and 7th segments are each provided with but a single pair of small sacks. Experimental evidence is adduced to prove that the eversion of these sacks is a voluntary act on the part of the insect, brought about by blood pressure, and that when everted these organs subserve a respiratory function. To distinguish them from tracheal and vascular gills *Haase* designates them "*Blutkiemen*."

The study of these peculiar organs naturally leads to a consideration of the Collembolan collophore, to which *Haase* also ascribes a respiratory function. Since he has not yet completed his study of this organ, his

remarks are meagre, and, I believe, open to some objection. Thus, in disregard of *Ryder's* observation on the embryo *Anurida*, he supposes the bifurcate, protrusible and glandular portion of the collophore to be derived from a pair of eversible sacks apposed in the median ventral line. . On page 373 he remarks: "Wie zuerst J. Wood-Mason hervorhob, ist die Entstehung des Ventraltubus der Collembola auf die Verschmelzung eines Abdominalsackpaares, wie sie bei Thysanuren auftreten, zurückzuführen, und in Uebereinstimmung damit ist auch bei den weniger rückgebildeten Formen die Bilateralität der Endsäckchen noch deutlicher ausgeprägt." He is careful not to maintain an homology between the pleuropodia of insect embryos and the eversible sacks of the Thysanura, though he agrees with *Graber* in ascribing to the pleuropodia a respiratory function. The wish to homologize the collophore with a pair of eversible sacks seems to have prevented *Haase* from seeing the at least equally probable homology between the collophore and the pair of appendages on the first abdominal segment of *Campodea* and between these last appendages and the pleuropodia of insect embryos — an homology which I could only surmise, but which *Haase's* own observations now render very probable.

Though *Haase* regards both the Ventralsäckchen and the collophore as respiratory organs, he nevertheless believes them to have arisen from what were originally glandular structures. This is very clearly expressed in the following paragraphs, quoted because they make to a certain extent for my theoretical conclusions in regard to the pleuropodia.

"In der That ist es wahrscheinlich, dass die Ventralsäcke der Symphylen, Chilognathen und Thysanuren auf weit verbreitete drüsige Bildungen zurückzuführen sind. Um nur die Antennaten zu berühren, so liegen die verschiedenen Organe alle nahe der Beinwurzel an der Unterseite order an entsprechenden Stellen der Bauchplatten, auch scheint ihr Bau auf *ein* Schema zurückführbar, auf eine Einstülpung der Chitinhaut, die über drüsigem Epithel liegt und entweder als Coxal-order Cruraldrüse dem Beine fest eingefügt ist order als Ventralsäckchen willkürlich durch Blutfüllung vorgestülpt und durch Muskeln zurückgezogen werden kann." After mentioning the coxal and crural glands of *Peripatus* and the *Myriopoda*, and describing the peculiar coxal secretion of Lithobiids, *Haase* continues: "Es ist nun sehr wahrscheinlich, dass diese (the eversible sacks) als Derivate von Drüsen aufzufassen sind, welche ihre secernirende Funktion mit der respiratorischen vertauschten, wie dies ähnlich von der Umwandlung von Hautdrüsen zu Tracheen angenommen wird. Auf die ursprünglich drüsige Natur der Hüftsäckchen deuten wohl noch die Riesenkerne in der Matrix derselben bei *Scolopendrella* und *Campodea*.

"Die rein drüsige Natur homologer Gebilde tritt uns, vielleicht sekundär unter den Thysanuren bei *Japyx* entgegen, wo bei *J. gigas* und *J. solifugus* kompakte Drüsenzellhaufen auftreten, deren Sekret sich in feine Hohlhaare ergiesst. Dass ähnliche Organe, wie die von *Japyx* anch die Vorläufer der respiratorischen Säckchen sein konnten, ergiebt sich schon

daraus, dass letztere bei *J. gigas* an derselben Stelle, wenn auch in unvollkommener Form, am zweiten Abdominalsegment auftreten.

Die ursprünglich drüsige Natur der Bauchsäcke von *Machilis* scheint, wie durch die eigenartige Matrixlage, so auch durch die langen gereihten Haare an der Dorsalseite der eingestülpten Säckchen bezeichnet zu sein, die mit verkümmerten einzelligen Hautdrüsen in Verbindung stehen."

BIBLIOGRAPHICAL LIST.

'84 Ayers, H.
On the Development of *Oecanthus niveus* and its parasite *Teleas.*
Mem. Bost. Soc. Nat. Hist., Vol. 3, No. 8, 1884.

'80 Balfour, F. M.
Notes on the Development of the Araneina.
Quart. Journ. Micr. Science, Vol. 20, 1880.

'87 Bruce, A. T.
Observations on the Embryology of Insects and Arachnids.
Baltimore, 1887.

'70 Buetschli, O.
Zur Entwicklungsgeschichte der Biene.
Zeitschrift für wiss. Zoologie. Bd. 20, 1870.

'85 Carnoy, J. B.
La Cytodiérèse chez les Arthropodes.
"La Cellule," 1885.

'89 Cholodkovsky, N.
Studien zur Entwicklungsgeschichte der Insecten.
Zeitschrift für wiss. Zoologie Bd. 48, Heft 1, 1889.

'87 Claus, C.
Lehrbuch der Zoologie.
4. Auflage; page 486. 1887.

87 Croneberg, A.
Ueber ein Entwicklungsstadium von *Galeodes.*
Zoolog. Anzeiger No. 247, 1887.

'61 Gerstaecker, A.
Ueber das Vorkommen von ausstülpbaren Hautanhängen am Hinterleibe von Schaben.
Archiv für Naturgeschichte, 1861, page 107–115.

'77 Graber, V.
Die Insecten, 2. Theil, 1877.

'88 Graber, V.
Ueber die Polypodie bei den Insectenembryonen.
Morph. Jahrb. Bd. 13, Heft 4, 1888.

'89 Graber, V.
Ueber den Bau und die phylogenetische Bedeutung der embryonalen Bauchanhänge der Insecten.
Biolog. Centralbl., Bd. 9 No. 12, August 15, 1889.

'84 Grassi, B.
Intorno allo Sviluppo delle Api nell' Uovo. Atti dell Acad. Gioena di Scienze Nat. in Catania. Ser. 3, vol. 18, 1884.

'87 Haase, E.
Die Vorfahren der Insecten.
Abhandl. d. Gesell. "Isis." Dresden. Bd. 11, 1887.

'89 Haase, E.
Zur Anatomie der Blattiden.
Zoolog. Anzeiger No. 303. March 25, 1889.

'89 Heider, K.
Die Embryonalentwicklung von Hydrophilus piceus, L. I. Theil. Jena, '89.

'82 Klemensiewics, S.
Zur näheren Kenntniss der Hautdrüsen bei den Raupen und bei *Malachius*. Verhandl. d. zool. bot. Gesell. Wien, 32. Jahrg., 1882, page 459–474.

'82 Korotneff, A.
Die Embryologie von *Gryllotalpa*.
Zeitschrift für wiss. Zoologie. Bd. 41, Heft 4, 1885.

'71 Kowalevsky, A.
Embryologische Studien an Würmern und Arthropoden.
Mem. de l' Acad. Imp. d. Sciences de St. Petersb. Tome 16, Ser. 7, No. 12, 1871.

'60 Leuckart, Fr.
Ueber die Geruchs-und Gehörorgane der Krebse und Insecten.
Reichert und Du Bois Reymond's Archiv. für Anatomie, 1860.

'86 Leunis, J.
Synopsis der Thierkunde.
3. Auflage., 1886, page 419.

'86 Locy, W. A.
Observations on the Development of *Agelena naevia*.
Bull. of the Mus. of Comp. Zool. Vol. 12, No. 3, 1886.

'87 Loman, J. C. C.
Freies Jod als Drüsensecret.
Tijdschr. Nederl. Dierk. Ver. Deel 1, 1887.

'73 Lubbock, Sir John.
Monograph of the Collembola and Thysanura.
Ray Society. London, 1873.

'86 Marx, Geo.
Notes on *Thelyphonus.*
Entomologica Americana Vol. 2, 1886–1887.

'89 Maynard, C. J.
The defensive plands of a species of Phasma, *Anisomorpha buprestoides*, from Florida.
Contributions to Science Vol. 1, No. 1, April, 1889.

'88 Minchin, E. A.
Note on a New Organ and on the Structure of the Hypodermis in *Periplaneta orientalis.*
Quart. Journ. Micr. Science. New Series No. 115, Vol. 29, part 3, 1888.

'87 Morin, J.
Zur Entwicklungsgeschichte der Spinnen.
Biolog. Centralbl. Bd. 6, 1887.

'86a Mueller, F.
As maculas sexuaes dos individuos masculinos das especias *Danais erippus* e *D. Gilippus.*
Arch. Mus. Nac. Rio Janeiro. Vol. 2, 1879, page 25–29. (1886.)

86b Mueller, F.
Os orgaos odoriferos dos especias *Epicalia Acontius*, Lin. e de *Myscelia Orsis*, Dru.
Arch. Mus. Nac. Rio Janeiro. Vol. 2, 1879. page 31–35. (1886.)

'86c Mueller F.
Os orgaos odoriferos nas pernas de certos Lepidopteres.
Arch. Mus. Nac. Rio Janeiro. Vol. 2. 1879. page 37–46. (1886.)

'86d Mueller, F.
Os orgaos odoriferos da *Antirrhoea archaea.*
Arch. Mus. Nac. Rio Janeiro. Vol. 3, 1880, page 1–7. (1886.)

'86e Mueller, F.
A prega costal das Hesperideas.
Arch. Mus. Nac. Rio Janeiro. Vol. 3, 1880, page 41–50. (1886.)

'89 Nusbaum. J.
Zur Frage der Segmentirung des Keimstreifens und der Bauchanhaenge der Insectenembryonen.
Biol. Centralbl. Bd 9 No. 17, Nov. 1, 1889, page 516–522.

'87 Oudemans, J. T.
Bijdrage to de Kennis der Thysanura en Collembola.
Academische Proefschrift, Amsterdam. 1887.

'89 **Oudemans, J. T.**
Ueber die Abdominalanhaenge einer Lepismide (*Thermophila furnorum*, Rovelli.)
Zoolog. Anzeig. No. 311. Juli, 1889.

'81 **Packard, A S.**
Scolopendrella and its position in nature.
American Naturalist. Vol. 15 No. 9. September, 1881.

'86 **Packard, A. S.**
The fluid ejected by Notodontian Catterpillars.
American Naturalist. Vol. 20, 1886.

'84 **Patten, W.**
The development of Phryganids with a Preliminary Note on the Development of *Blatta germanica.*
Quart. Journ. Micr. Science. Vol. 24, 1884.

'86 **Poulton, E. B.**
Notes in 1885 upon Lepidopterous larvæ and pupæ, including an account of the loss of weight in the freshly formed Lepidopterous pupæ, etc.
Trans. Ent. Soc. London, page 137–179. 1886.

'44 **Rathke, H.**
Zur Entwicklungsgeschichte der Maulwurfsgrille (*Gryllotalpa vulgaris.*)
Müller's Archiv für Anat. und Phys. Jahrg. 1844.

'81 **Ryder, J. A.**
The structure, affinities and species of *Scolopendrella.*
Proc. Acad. Nat. Science. Philadelphia, 1881.

'86 **Ryder, J. A.**
The development of *Anurida maritima*, Guerin.
American Naturalist. Vol. 20, 1886 page 299–302.

'59 **Say, Thos.**
Complete Writings. Edited by John L. Leconte. 2 vols. 1859. page 84, Vol I.

'86 **Scudder, S. H.**
A systematic Review of our Present Knowledge of Fossil Insects, including Myriopods and Arachnids.
Bulletin of the U. S. Geol. Survey. No. 31. 1886.

'86 **Smith, J B.**
Scent organs in some Bombycid Moths. Entomologica Americana, Vol. 2, No. 4, page 79–80, 1886

'82 Tichomiroff, A.
On the development of the silk-worm (*Bombyx mori*) in the egg.
(In Russian) Contrib. from the Laboratory of the Zool. Museum.
Moskau 1 Vol. 1882.

'89 Watase, S.
On the Morphology of the Compound Eyes of Arthropods.
Studies from Biolog. Laboratory, Johns Hopkins University.
Vol. 4, No. 6, 1889.

'63 Weismann, A.
Die Entwicklung der Dipteren im Ei nach Beobachtungen an *Chironomus* spec. *Musca vomitoria* und *Pulex canis.*
Zeitschrift für wiss. Zoolog. Bd. 13, 1863.

'89 Voeltzkow, A.
Entwicklung im Ei von *Musca vomitoria.*
Arbeiten aus dem zoolog. zootom. Institut in Wuerzburg.
Bd. 9, Heft 1, 1889.

'89a Wheeler, W. M.
Homologues in Embryo Hemiptera of the Appendages of the First Abdominal Segment of other Insect Embryos.
American Naturalist Vol. 33, July, 1889.

'89b Wheeler, W. M.
Ueber drüsenartige Gebilde im ersten Abdominalsegment der Hemipterenembryonen.
Zoolog. Anzeiger No. 317, September 30. 1889.

'89c Wheeler, W. M.
The Embryology of *Blatta germanica* and *Doryphora decemlineata.*
Journal of Morphology, Vol. 3, No. 2, Sept., 1889.

'88 Will, L.
Entwicklungsgeschichte der viviparen Aphiden.
Zoolog. Jahrb. Bd. 3, Heft 2, 1888.

EXPLANATIONS OF THE PLATES.

PLATE 1.

Fig. 1. Lateral view of a *Blatta* embryo 16 days old [during revolution] *a*, amnion; *sr*, serosa; *lb*, labrum; *md*, mandible; mx_1 first maxilla; mx^2, second maxilla; *at*, antenna; p^1, p^2, p^3, thoracic limbs; *ap*, pleuropodium, or appendage of the first abdominal segment.

Fig. 2. Longitudinal section through the metathoracic and first three abdominal appendages of a *Blatta* embryo 12 days old; p^3, metathoracic leg; *ap*, ap^2, ap^3, first, second and third abdominal appendages; *ms*, mesodermic somite; *ecd*, ectoderm.

Fig. 3. Longitudinal section through the pleuropodium of a *Blatta* embryo 14 days old; *ecd*, ectoderm; *ms*, mesoderm; *v*, vacuole.

Fig. 4. Three cells from the same series of sections as Fig. 3. Zeiss hom. immers., $\frac{1}{12}$ oc. II. *v*, vacuole; *nc*, plastine nucleolus.

Fig. 5. Five nuclei from a longitudinal section of the pleuropodium of a *Blatta* embryo 20 days old; drawn with focus on the equatorial plane. Magnification same as in Fig. 4.

Fig. 6. Longitudinal section of a pleuropodium of a *Blatta* embryo 19 days old. *pd*, peduncle; *cv*, cavity; *cn*, constriction; *v*, series of vacuoles.

Fig. 7. Longitudinal section from a pleuropodium of a *Blatta* embryo 20 days old. Reference letters same as in Fig. 6.

Fig. 8. Longitudinal section of a pleuropodium from a *Blatta* embryo about 25 days old. *n*, nuclei; *pl*, protoplasm.

Fig. 9. Section through a pleuropodium of a *Blatta* embryo 26 days old. *n*, nuclei; *pl*, protoplasm.

PLATE 2.

Fig. 10. Longitudinal section through a pleuropodium of an embryo *Periplaneta orientalis*, in a late stage, after the closure of the body walls in the median dorsal line and the secretion of the first cuticle. *ecd*, ectoderm; *ms*, mesoderm [connective tissue]; *pl*, protoplasm issuing from the distal end of the organ; *t*, tips of pleuropodial cells; *v*, vacuole; *x*, two pleuropodial cells about to pass through the peduncle into the body cavity of the embryo.

Fig. 11. Longitudinal sections through a pleuropodium of an embryo *Mantis carolina* before revolution; *ecd*, ectoderm; *ms*, mesoderm; *x*, point where the ectoderm is comparatively thin; *p*, one of the thoracic appendages; *ap*, pleuropodium.

Fig. 12. Cross section through one of the pleuropodia of an embryo *Xiphidium ensiferum* during revolution; *sr*, serosa; *as*, amniotic secretion; *ct*, chitinous cuticle; *ap*, pleuropodium; *cv*, cavity; *p*, one of the thoracic appendages; *ecd*, ectoderm; *ms*, mesoderm.

Fig. 13. Section through the base of one of the pleuropodia of *Xiphidium ensiferum* just before hatching; *ap*, pleuropodium; *pd*, peduncle, inserted in a pit of the hypodermis *ecd*, which has secreted its second cuticle, *ct*; *s*, granular secretion.

Fig. 14. Cross section through the same pleuropodium; *s*, granular secretion; *cv*, cavity.

Fig. 15. Cross section through the coilophore of *Anurida maritima* [adult]; *ct*, cuticle; *hy*, large nucleus of the hypodermis; *pg*, hypodermic pigment; *ct*, delicate cuticle covering the glandular part of the organ; *s*, granular secretion; *gl*, gland cells; *ms*, retractor muscles of the glandular hypodermis; *cn*, connective tissue; *st*, sternum; *bl*, blood.

Fig. 16. Surface view of the collophoral (first abdominal) segment of the adult *Anurida maritima*. p^3, metathoracic legs; *ab*, first abdominal segment; *c*, collophore.

PLATE 8.

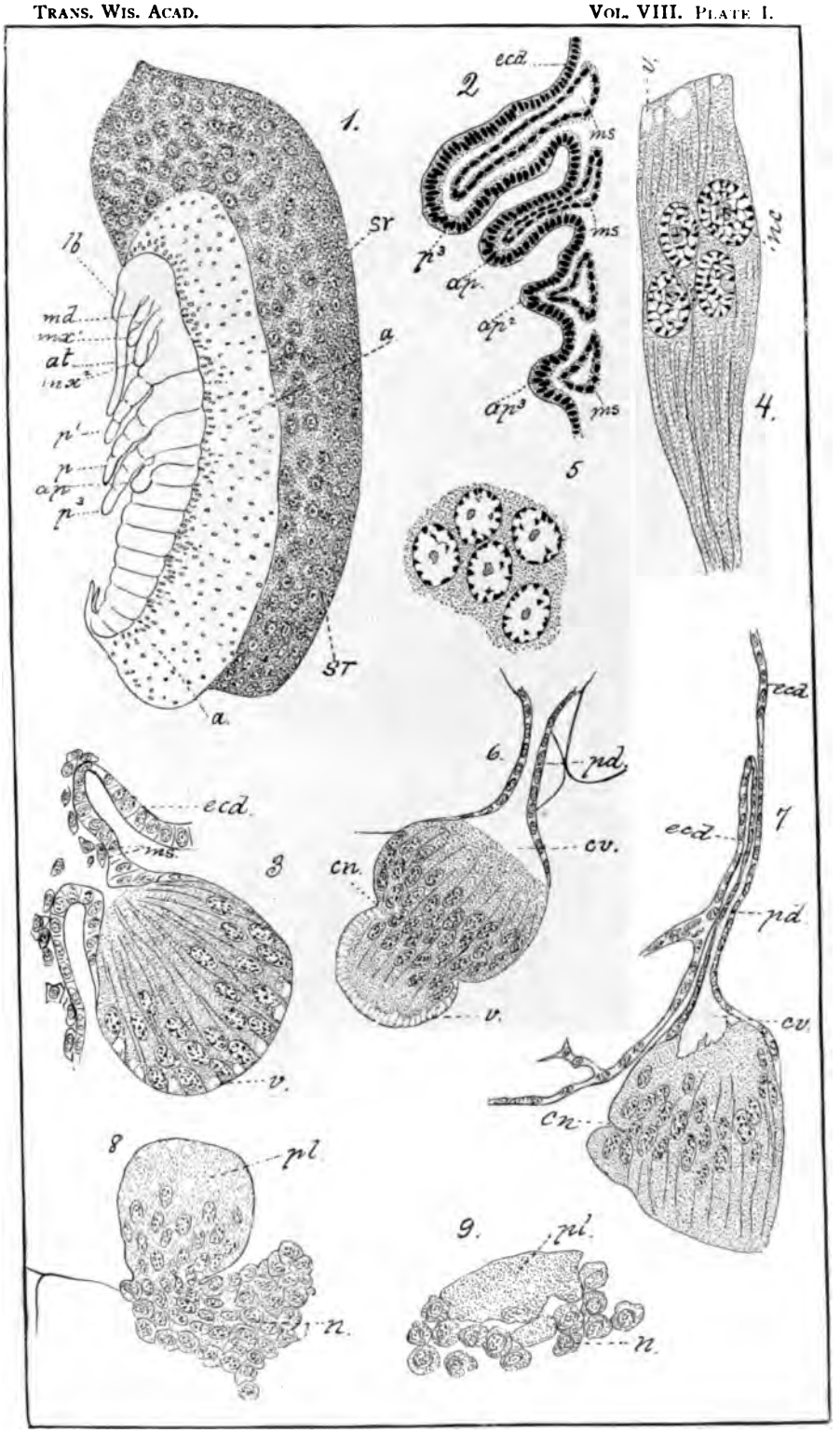
Fig. 17. Half of a transverse section through the first abdominal segment of the embryo *Zaitha fluminea* during revolution. *ap*, pleuropodium; *s*, penicillate secretion; *ecd*, ectoderm; *ent*, entoderm; *vt*, yolk; *vp*, vitellophag; *cn*, connective tissue; *ms*, muscle; *ad*, corpus adiposum; *cb*, cardioblast; *gl*, ganglion of the first abdominal segment.

Fig. 18. Three cells from a pleuropodium of *Zaitha fluminea* enlarged. *x*, granular and widened inner ends of cells; *h*, hyaline and attenuated outer ends of cells; *s*, threads of secretion. Zeiss. homog. immers. $\frac{1}{12}$ Oc. II.

Fig. 19. Longitudinal section of a pleuropodium of the embryo *Cicada septemdecim* during revolution. *ap*, pleuropodium; *s*, secretion;

as, amniotic secretion; *p*, one of the thoracic appendages; *ch*, chorion; *ecd*, ectoderm; *ms*, mesoderm; *ct*, connective tissue; *vt*, yolk.

Fig. 20. Portion of a transverse section through the ventral plate of a *Cicada* embryo before revolution. *a*, amnion; *ecd*, ectoderm; *ap*, pleuropodium forming as an apple-shaped thickening of the ectoderm; *gl*, ganglion of the first abdominal segment; *ms*, mesodermic tissue.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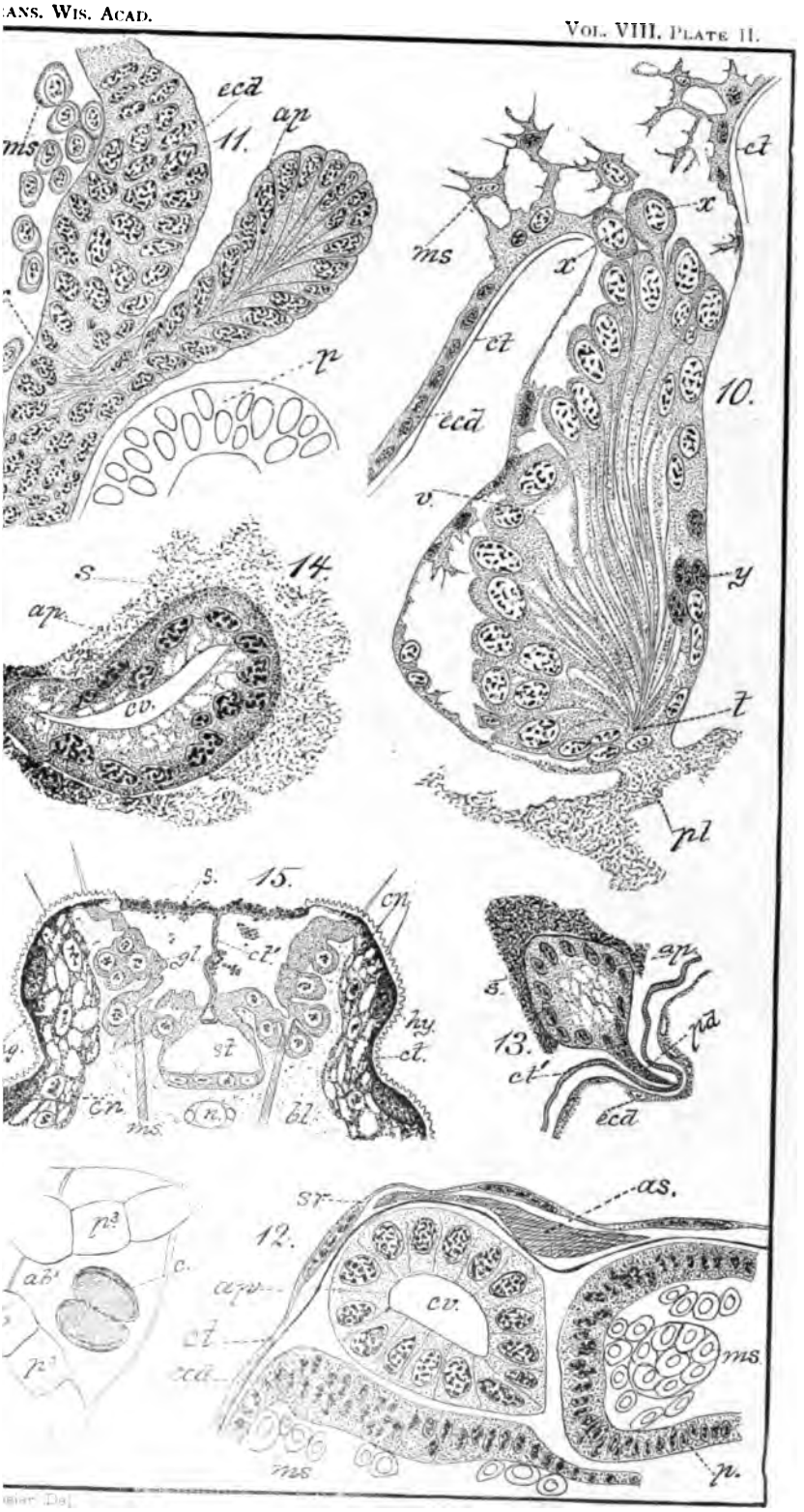
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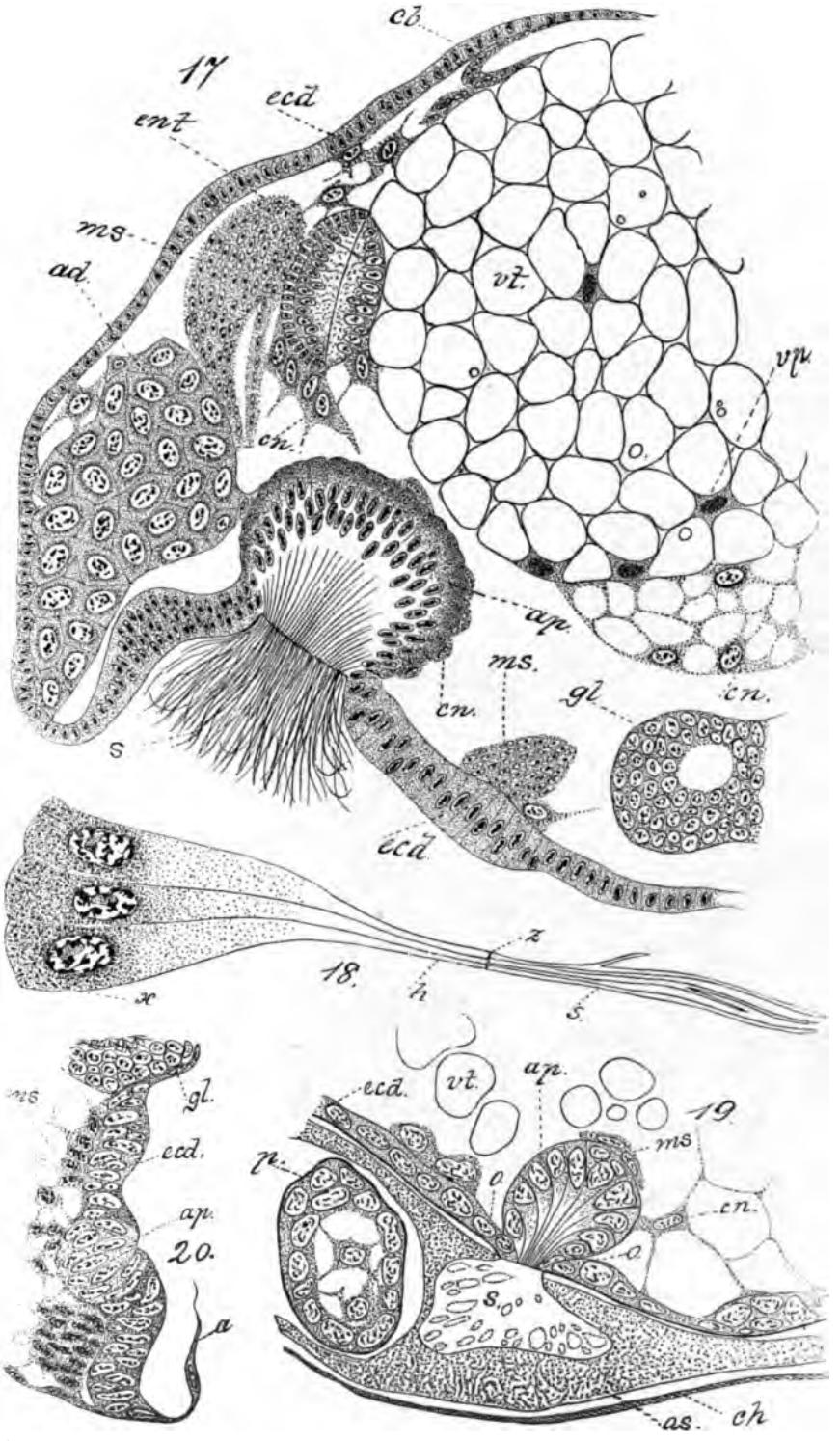
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SOME NEW THEORIES OF THE GREEK KA-PERFECT.

By CHAS. E. BENNETT.

In spite of all that comparative grammar has done to throw light upon the morphology of the different Indo-European languages, there yet remain in the individual languages a goodly number of formations without correspondence in any other language. As examples of such isolated formations may be cited the Greek passive aorists in *-ην* and *-θην*, the so-called *-n-* or weak declension of the Germanic languages, and the gerundive of the Latin.

With regard to these and similar formations two theories might at first suggest themselves:

First, that we have to do with primitive Indo-European formations, the traces of which have disappeared in the other languages and are preserved in one alone, or

Secondly, that the formation does not go back to the Indo-European *Ursprache*, but is a new creation of the particular language in which it is found.

As a matter of fact we at once discard the theory that any formation of the nature in question existed as such in the Indo-European *Ursprache*. Unless we have the combined testimony of at least two groups of languages as to the primitive character of a formation we shall not be justified in attributing it to the *Ursprache*. We must rather view such a formation as due to the specific agency of the particular language in which it is found, as produced by way of analogy or association with other formations of the same language, by the use of inflectional material already at hand.

It is in this way that we explain the origin of the weak or *-n-* declension in the Germanic group. The *-n-* declension arose simply from a wider extension and more frequent application of endings which were originally peculiar to *-n*-stems, such as Latin *nomen*, Greek *δαίμων*, *etc.* So in Greek the so-called 1st and 2nd aorists passive in *-ην* and *-θην* were originally nothing more than intransitive 2nd aorists active of the *-μι* form, *i. e.*, constructed after the analogy of forms like *ἔβλην ἔστην*, *etc.* The formation in *-ην* was the earlier, as in *ἐπλάκην*, *ἐστάλην*, *ἐφάνην*, *etc.*, while the so-called first aorists in *-θην* are formed after the analogy of those in *-ην*, under the influence of such presents as *σχέθω*, *πλήθω*, *φθίθω*, *βιβάσθω*, *νεμέθω*, *ἄχθομαι*, *νήθω*, *μινύθω*, *πρήθω*, *κνήθω*, *etc.*

The above are cited simply as examples to illustrate the methods by which we may expect to explain similar formations peculiar to a single

language, and which therefore cannot be referred to the *Ursprache* for their origin. Such a formation is the Greek perfect in *-κα*. No other Indo-European language presents any trace of it, and we therefore assume that we have to deal with a formation which has developed itself on Greek ground by way of association or analogy with some other inflectional form of the Greek language.

There have lately appeared several new theories in explanation of the *-κα*-perfect. The two most important of these have emanated from the school of the so-called "*Junggrammatiker*," and have been propounded by the heads of the school, one by Prof. Brugmann of Leipsic, the other by Prof. Osthoff of Heidelberg. A third is that of Felix Hartmann.

Before taking up the consideration of these theories, let us state more precisely the problem to be solved. The oldest formation of the Greek perfect, was unquestionably by the suffix *-α*, appended to the strong form of the root, with the reduplication prefixed, *e. g.*,

root *λειπ-*, perf. *λέ-λοιπ-α*.
root *πειϑ-*, perf. *πέ-ποιϑ-α*.
root *φευγ-*, perf. *πέ-φευγ-α*, earlier **πέ-φουγ-α*.

The Sanskrit formed its perfect in the same way, and there can be no doubt that the formation goes back to the *Ursprache*, for its origin. But by the side of this Greek perfect in *-α* we find in the oldest monuments of the language also a considerable number of perfects in *-κα*. As time goes on this number increases, and in the Attic of the 4th century B. C. the *-κα* perfect is the regular formation for all verbs except stems in labial and palatal mutes and a few others, which have retained the old *-α-* formation.

The problem before us is to explain this *-κα;* why we have *-κα* instead of *-α*.

BRUGMANN'S THEORY.

Brugmann's theory appeared first in Vol. XXV. of *Kuhn's Zeitschrift für Vergleichende Sprachforschung*, p. 212 ff., 1879.

As he omits some of the earlier theories we may mention them here.

An examination of the perfects used by Homer discloses the fact that but an extremely small number of *-κα-* forms occurs. While perfects in *-α*, as *πέποιϑα, εἴληχα, εἴληρα, κέκραγα, etc.*, are very numerous, the *-κα*-perfects found in the Iliad and Odyssey together number only twenty. As examples may be mentioned, *βέβηκα, βέβληκα, δέδυκα, ἕστηκα, πέφυκα, τέϑηκα, τέτληκα.* All the Homeric *-κα*-perfects, moreover, are from vowel stems. There are no Homeric *-κα*-perfects from consonant stems, such as the later Attic *πέπεικα, ἔσταλκα ἔφϑαρκα, πέφαγκα.*

This circumstance led Thiersch and subsequently Ahrens to explain the *κ* as inserted between two vowels for the purpose of avoiding hiatus, so that according to this theory *βέβηκα* would be explained as arising from **βέβηα*, by the insertion of *κ*; so *ἕστηκα* from an imaginary **ἕστηα*. As

a ground for this explanation Thiersch and Ahrens cited οὐκέτι and μηκέτι. But the κ here belonged originally to the οὐκ in all probability, so that οὐκέτι is for οὐκ-έτι (not for an earlier *οὐ-έτι), while μηκέτι is formed after the analogy of οὐκέτι.

It is scarcely necessary to add that a theory involving such an extraordinary phonetic phenomenon as the bodily insertion of κ, a change not only not elsewhere exemplified in Greek, but also without analogy in other languages, is unworthy of further consideration to-day, when the inviolability of phonetic laws is so insisted upon by even the less rigid investigators.

Curtius, in his earlier work, the *Tempora und Modi*, followed Thiersch and Ahrens, but in his *Verbum der Griechischen Sprache*, he propounds the following explanation of the -κα- perfect. He designates the -κα as a "*stammbildendes Element.*" He further assumes that nominal stems were first formed with this suffix; and from these nominal stems verb-stems, just as the verb-stems in -να-, -νυ-, -νο-, -ανο-, -το-, -σκο-, are, by Curtius, in their origin, assumed to be nominal stems. Curtius further says, "Assuming that there was a nominal stem *βᾱ-κᾰ (Ion. *βη-κᾰ) then from this we might have a reduplicated βέ-βᾱ-κα (Ion. βέ-βη-κα), and such reduplicated stems might, in the period when the verbal forms were still undetermined, establish themselves here and there in the perfect by the side of the shorter forms in -α."

To this theory of Curtius Brugmann presents the following objections:

1. Where are these nominal stems in -κα? The language does not seem to have had them. We should expect them to exist in some abundance; but we find only a very few. We may cite θήκη and σωκός; but from θήκη we could hardly directly explain the form τέ-θεικα as the vocalism of the two words is different, one having η the other ει. Nor can we satisfactorily explain the aorist ἔθηκα from θήκη. For θήκη means 'chest, vessel,' and the testimony of the Sanskrit *dhâ-kâ*, which has the same meaning, seems to indicate that in the *Ursprache* the word had this specialized sense of the root *dhê-*. It is difficult to comprehend how a denominative aorist or perfect in the sense of 'put' should be formed from a noun meaning 'holder.'

2. Curtius speaks of a form βέβηκα establishing itself by the side of a form *βέβηα at a time when the verbal inflections were still undetermined. Brugmann with propriety inquires when Curtius conceived this to have been. Was it subsequent to the period of the *Ursprache?* If so, he should remember that the verbal inflections were then no longer undetermined. The substantial unity of the verbal inflection of the separate languages shows this. Or does Curtius mean the period of the *Ursprache?* If so he should consider that we can not pretend to explain a formation which has confessedly developed upon specific Greek ground, by referring to the *Ursprache*, or any conditions which may have prevailed in it.

To these two leading objections of Brugmann might be added another,

viz.: Is it conceivable that denominative verbs in simple -ω should be formed from stems in -ᾱ (Ion., Attic -η) *e. g.*, a **βήκω* from **βήκη*? Could we expect anything else from **βήκη* than **βηκάω* or **βηκέω*? Would not the overwhelming abundance of denominatives like *τιμάω*, *ἀράομαι*, *φιλέω*, *etc.*, be a sufficient assurance that, even admitting the existence of *βήκη*, we should never have had a form **βήκω* from it, from which to produce a perfect *βέ- βηκ-α*?

In view of the objections which Curtius's theory raises against itself Brugmann thinks we must try in another way to solve the problem of the *-κα-* perfect. From an examination of verbal formations in *-κ-* Brugmann finds six which are pre-Homeric. These are:

ὀλέκω
δώκοι (on the Idalian Bronze Tablet, line 16.)
δειδίσσομαι (for *δειδίκιομαι*.)
The three aorists *ἔδωκα*, *ἔθηκα*, *ἧκα*.

To all of these forms correspond perfects in *-κα*, which likewise seem to belong to the primitive stages of the language. These are *ὀλώλεκα*, *δέδωκα*, *δείδοικα* (*i. e.*, **δέδϝοικα*), *τέθηκα* (*τέθεικα*), *εἷκα*.

Brugmann subjects each of these verbs to a careful examination with reference to determining whether their *-κ-* not only is pre-Homeric but possibly even dates from the *Ursprache*. He arrives at a negative conclusion with reference to the forms *ἧκα*, *ἔθηκα*, *δειδίσσομαι*, with their corresponding perfects *εἷκα*, *τέθηκα* (*τέθεικα*), *δείδοικα*.)

With reference to *ὀλέκω* and its perfect *ὀλώλεκα*, he finds it impossible to reach a decision, owing to its obscure etymology. *ἔδωκα* with its perfect *δέδωκα* and its present optative *δώκοι* is the only one of the *-κ*-formations which Brugmann concedes goes back to the *Ursprache* for its origin.

This form *δέδωκα* Brugmann derives from the root *δωκ-* and identifies with the Sanscrit *da-dâç-a*. The correspondence in form between the two is exact. The signification also of the Sanskrit *da-dâç-a* is the same as that of *δέδωκα*. For the Sanskrit root *dâç-* means 'give, vouchsafe, offer,' just as does the root *dâ-* = Greek *δω-*.

The so-called aorist active *ἔδωκα* Brugmann also derives from this same root *δωκ-* (Sanskrit *dâç-*). This *ἔδωκα* is for an original **ἔδωκ-m*, *m* representing the vocalic nasal or "nasalis sonans," which when unaccented regularly develops in Greek as *α*; just as the Rhenish Germans say *gegange* for *ge-gang-n* (*i. e.*, *gegangen*), *geritte* for *geritten* (*i. e.*, *geritten*), *obe* for *obm* (*i. e.*, *oben*). Other examples in Greek of the development of the vocalic nasal or "nasalis sonans" are *ἔλυσα* (for **ἔλυσm*), *γεγράφαται τετράφαται* (for **γεγράφ-ntαι*, *etc.*; *cf.* *βε-βούλευ-νται*).

According to the above view of the forms *ἔδωκα* and *δέδωκα* we have, in the different systems of the Greek verb *δίδωμι*, to deal with two roots, one root *δω-* corresponding to the Skrt. *dâ-* and another *δωκ-* corresponding to Skrt. *dâc-* Both roots are nearly identical in meaning and

hence have become united in one verb: just as frequently the same thing occurs where the different roots are clearly distinct, *e. g.*,

ὁράω, ὄψομαι, εἶδον
φέρω, οἴσω, ἤνεγκον.

δέδωκα therefore is δέ-δωκ-α, *i. e.*, a regularly formed perfect from the root δωκ- with the ending -α, the regular ending of the perfect both in Greek and Sanskrit, as seen in πέποιθα, λέλοιπα, πέφευγα and numerous other similar forms; and it is from this one form that Brugmann conceives the entire category of -κα- perfects to have arisen, and in the following way. After ἔδωκα and δέδωκα had become part and parcel of the verbal system of δί-δω-μι they were mentally referred to the root δω- also, and the ending -κα was felt as a tense-suffix.

As soon as it was felt as such it began to be employed in the formation of other perfects with long vowel roots, *e. g.*, ἕστηκα (στη-), βέβηκα (βη-), πέφῡκα (φῡ-).

Brugmann thinks he discovers a particular reason why the -κα- formation was so readily adopted by the long vowel stems. The original inflection of the singular of the perfect indicative of the root δω-, for example, must have been:

* δέ- δω- α
* δέ- δω- ς (-θα)
* δέ- δω- ε

By contraction this must have early given:

* δέδω
* δέδως
* δέδω

These forms were felt to lack the distinctive perfect character and were likewise identical in the 1st and 3rd singular. Hence it was that the language readily availed itself of such formations as ἕστηκα, βέβηκα. πέφῡκα. It is at about this stage in the history of the perfect that th Homeric poems belong. The -κα-perfects in Homer are almost exclusively from long vowel roots; but short vowel roots are also just beginning to adopt the -κα- formation, *e. g.*, βεβίηκα, δεδείπνηκα, *etc.* Still later and subsequent to Homer are the formations from consonant stems, such as ἕσταλκα, ἔφθαρκα, πέπεικα, ἤγγελκα, τεθαύμακα.

The theory that one form like δέδωκα should have been the type that has called hundreds of others into existence seems at first, perhaps, too remarkable to be lightly credited; yet similar phenomena are well attested for other languages. Thus in Old Bulgarian the first singular of the verb in the present indicative ended almost always in *a* = original Indogermanic *ō*. Only four verbs had the ending *-mi*, *viz*: *jesmi*, *vĕmi*, *dami*, *jami*. Yet these four verbs have been the type from which all verbs in the modern Slovenian and Servian languages form their 1st person singular present indicative in *-m*. So we have hundreds of forms from four alone. So also

in German we have in the nominal inflections the frequent plural ending *-er* producing Umlaut of the root syllable, *e. g.*, *Thal, Thäler; Buch, Bücher; Grab, Gräber; Irrthum, Irrthümer; Kalb, Kälber,* and very many others. All of these are modern except *Kalb, Kälber,* which must be considered as having furnished the starting point for the whole category. The plural *Kälber* therefore in the number of forms it has called into existence would furnish an exact parallel to *δέδωκα*.

An interesting and instructive illustration is furnished also by the Italian. The Latin *steti, stiti* became in Italian *stetti*. This form was felt as consisting of *st-* as root and *-etti* as the ending. So by the analogy *sto, stare, stetti,* we got in Italian from *do, dare,* the perfect *detti* instead of *diedi* (Latin *dedi*). The ending *-etti* was then applied to other verbs, such as *vendetti, fremetti, credetti, dovetti* and many others. I have not been able to determine the exact extent of the application of this ending, from lack of the requisite books of reference, but am convinced that it is quite extensive.

The example is at all events a striking one of how even one single form can furnish the model after which innumerable others may be constructed. *Stetti,* therefore, would furnish a complete analogy of what we have claimed for *δέδωκα*. It is historically certain for *stetti*; it is therefore very possible for *δέδωκα*.

The objection then to one form's being the starting point for many would seem to be met by the above considerations.

Hermann von der Pfordten in his *Geschichte des griechischen Perfects* calls attention further to the fact that the other perfects from stems in *-κ-* as:

δέδορκ-α (root *δερκ-*)
μέ-μυκ-α (root *μυκ-*)
τέ-τηκ-α (root *τηκ-*)
μεμηκ-ώς (root *μηκ-*)
πέ-φρικ-α (root *φρικ-*)
ἔοικ-α (root *Fεικ-*)

may have contributed to the illusion that *-κα* was a tense suffix and so have assisted in its application to other roots.

In fact von der Pfordten thinks that even the so-called *-κα-* aorists *ἔδωκα, ἔθηκα, ἧκα* may have contributed their share in the same direction, especially when one considers the great frequency of these words (some 500 times) in the Homeric poems, the very stage of the language at which we find the *-κα-* formation just beginning to assume greater proportions.

Brugmann's theory then may be summed up in the following words:

There was in Greek an early confusion of two roots of the same meaning, *δοκ-* and *δωκ-*, *δω-* being used for the present and future, *δωκ-* for the aorist and perfect. By reason of this confusion the ending of *δέδωκα* was felt as *-κα* instead of *-α*, as it really was; and being once felt as a tense suffix, it

was given a wider application, being appended first to other long vowel stems as ἡ-, θη-, στη- φῡ-, afterward to short vowel stems, and eventually to some mute and all liquid stems.

This theory, it will be observed, explains the reason why we find the ending -κα applied first to long vowel stems; it is because it originated with such a stem, δω-. It explains further the origin of the aorists ἔθηκα, ἧκα, and two others not usually given in the grammars, ἔστηκα and ἔφρηκα. These aorists were formed after the analogy of ἔδωκα just as ἔστηκα after the analogy of δέδωκα.

It might seem strange, in view of this fact, that we do not find a similar wide extension of the -κα- aorist, just as of the -κα- perfect. The reason of course is plain. The same time suffix could not do duty for both tenses. The analogy might have taken its development in the line of the aorist, just as well as of the perfect, and if that had occurred, we should have looked upon it as perfectly natural; but it could not do double duty, serving both as a perfect and an aorist suffix.

As it is, the -κα- suffix developed in the perfect, and beyond a few -κα- aorists formed before the suffix had come to be felt as peculiar to the perfect, it took no further development in the line of the aorist.

Such is Brugmann's theory of the -κα- perfect. It is really less fanciful than one might be at first inclined to consider it. His theory is worked out with rigid method, nothing being assumed, which is inconsistent with known phonetic laws or unsupported by the analogy of the Greek itself and other languages. A demonstration, however, it can not be held to be. It is simply an extremely clever hypothesis supported by striking analogies.

It has met with recognition from German scholars such as von der Pfordten in his *Geschichte des griechischen Perfects*, as well as from Gustav Meyer in his *Griechische Grammatik*. While therefore we may not call it a proof we must admit that it suggests a plausible method by which the -κα- perfect *may* have developed.

We consider next

OSTHOFF'S THEORY.

For several years after Brugmann propounded his theory it enjoyed general repute as the only plausible explanation yet given of the problem, until the appearance in 1884, of Osthoff's *Geschichte des Perfects im Indogermanischen*. Herman Osthoff, the author of this work is professor of Sanskrit and comparative philology at Heidelberg, and a man of astounding ingenuity in solving the riddles of Indo-European grammar. His mind is constantly evolving a new solution of some knotty point of morphology, worked out with an elaborateness which anticipates every objection that can be raised against it. Although an intimate friend of Brugmann and with him the head of the school of "*Junggrammatiker*", yet he never could feel quite satisfied with Brugmann's theory of the origin of the -κα- perfect, which we have just considered above.

He consequently set to work to find some explanation which should be more satisfactory, and the result of his lucubrations is given us in a lengthy chapter of the work above cited, pp. 324–390.

Osthoff's theory is that we have in the Greek *-κα-* perfect the particle *κεν*; that *δέδωκα* is *δεδω + κεν*.

Let us proceed to the details. And first a few words on roots and the different forms they assume under different circumstances.

It is a generally accepted theory that roots appear under different forms in consequence of accentual conditions. Thus we explain

Skrt. *ás- mi*
ás- i
ás- ti

as having the full form of the root *as-* because accented on the root syllable; whereas the dual and plural forms

svás smás
sthás sthá
stás sánti

take the weakened form of the root *-s* because the accent is on the personal ending. So also in Greek we had originally **δι-δω̃-μι, *δι-δω̃-σι, *δι-δω̃-τι, *δι-δο-τόν, *δι-δο-τόν, *δι-δο-μέν, etc.*, with the strong form of the root *δω-* in the singular, because the accent stands on the root syllable, and the weak form *δο-* in the dual and plural, because the accent is on the personal ending. Of course this primitive accentuation was lost in Greek, before we know it historically as an independent language; the primitive accentual conditions disappeared with the rise of the three syllable law and of the recessive accent of the verb.

So also in the inflection of the noun in Greek. In words of the type of *πατήρ, μήτηρ, etc.*, we have the strong form of the stem *πατερ-, μητερ-* where the stem syllable is accented, as in the accusative singular *πατέρα;* nominative plural *πατέρες;* but we have the weak form of the stem *πατρ-* where the accent falls upon the case ending, as *πατρ-ός, πατρ-ί; πατράσι(ν)* also is formed from the weak stem *πατρ-*.

This variation of the form of the root in two, three and sometimes even four ways (called by the Germans *Stammabstufung*) extends to all parts of speech. It is not limited to nouns and verbs, in which the accent originally shifted, standing now upon the root syllable, now upon the ending, but may occur also in monosyllables, which by their varying force sometimes receive a decided stress and at other times are enclitic.

All parts of speech are equally liable to this change of form dependent upon stress-accent. The phenomenon is witnessed most frequently in case of nouns, adjectives and verbs; yet it occurs also (and this is at present the important point for us) in the case of particles; and we shall soon see that in *κα* we have simply another form of *κεν*, a form bearing the same relation to *κεν*, as our unaccented "the" does to our accented "thé"; or as "come" in "cm in" to our "cóme" in the phrase "you cóme."

The demonstration of this relationship depends upon the principles of the *nasalis sonans* theory, which was alluded to above in connection with ἔλυσα for *ἔλυσm; and ἔδωκα for *ἔδωκm. We there saw that this sonant nasal developed in Greek, when unaccented, into α; just as in many dialects in Germany the ending *-n* (*i. e. -en*) when unaccented becomes a short *e*-vowel, through the medium of the sonant nasal.

The full or strong form of the particle κεν is κεν. When unaccented it sinks to κ + the sonant nasal or *κn. This sonant nasal then regularly develops to α giving us κα; just as we have τατός, verbal from τείνω (root τεν-), for *τn-τός.

The Sanskrit, it may be mentioned, develops the sonant nasal in the same way; thus we have *ta-tás* for *tn-tás*, corresponding to Greek τα-τός; and *ta-nó-mi* in the 5th Sanskrit class (acc. to Bopp) for *tn-nó-mi*.

Nor is κεν the only illustration, among particles, of this variation of weak and strong form, this *Stammabstufung*.

We have another striking illustration in the case of the particle αυ, which has for its weak or unaccented form -υ. This unaccented form is seen in πάν-υ (*cf.* πᾶν) and further probably in ουτος, το-ύ-του, *etc.* It is doubtless the same as the Sanskrit particle *-u* and the Gothic *-u*, seen in the passive forms of the optative and imperative, as *nimada-u* and *nimainda-u*.

The same *Abstufung* holds similarly for many other particles, to which Osthoff has devoted some exhaustive consideration in the fourth volume of *Morphologische Untersuchungen*, pp. 222–277, in his consideration of what he calls the "*Tiefstufe im Indogermanischen Vocalismus.*" It is unnecessary to consider this matter further here.

We may now return to κεν. We have seen that we have to deal with two forms, κεν and κᾰ. There are to be sure two other forms of our particle *viz.* κε and κᾱ, but as they do not concern our present purpose, we omit any consideration of the question of their special origin, interesting as that might be. The form κα is confined pretty nearly to the Doric and Lesbic-Aeolic dialects in the historical period; yet this does not constitute any objection against its antiquity, or against its having at some time been in frequent use in all dialects.

So much for the morphological side of the particle. Let us now look at its probable signification.

The tradititional etymology of κεν has connected the word with the Skrt. *kám*, which means 'well, indeed, to be sure'; and even the latest scholars have signified their acceptance of this view, including among the latter Delbrück in his *Syntaktische Forschungen*, vols. I., and IV.; Ascoli, *Studj Critici* II., 231 ff; and Gustav Meyer in his *Greek Grammar*. Osthoff is the first to raise objections to this etymology; not, as he admits, because it is phonetically inadmissible, though he mentions one or two weak spots (which we shall have to omit here), but because he thinks he has a better etymology to propose. He thinks κεν identical with Skrt.

çám, an indeclinable adjective signifying "beneficent, advantageous, wholesome, good." This word, which has not yet become a particle in Sanskrit, Osthoff thinks became one in Greek and in the signification of the German *wol* united itself in its weak or unaccented form *κα* with the primitive inflection of the perfect: *e. g.*, *δέδω-*, to form the *-κα-* perfect, *δέδωκα*. *δέδωκα* would therefore mean "I have indeed given," or as Osthoff puts it in German, "*ich habe wol gegeben.*"

It is in fact this very correspondence in meaning between the Sanskrit *çám* and the German *wol* that leads Osthoff so decidedly to prefer the etymology of *κεν* which he proposes and advocates. He traces the development of the German *wol* from its Old High German force of "well," through the Middle High German, where it takes on the additional meaning of "quite, very, thoroughly, certainly," until it reaches that force, untranslatable in English, which it exercises with such frequency in the German of to-day, as for example in such expressions as "*Sie sind wol krank; das haben Sie wol gesehen.*" Osthoff believes *κεν* or *κα* has gone through the same course of development. The Sanskrit *çám* he considers to represent the original signification of *κεν*, namely "excellently," while in the historical period of the Greek language he thinks he finds clear traces of *κεν* in the same sense as Germam *wol* in its weak, almost pleonastic force.

The question that naturally first presents itself is: Does *κεν* actually have this force?

Delbrück, *Syntaktische Forschungen*, I., 90, expresses the opinion that while *κεν*, *ἄν* "*begleiten den conjunctiv und optativ durch alle inneren wandlungen, sie erzeugen dieselben nicht. Sie sind nur ein beredter ausdruck dessen, was auch durch den blossen conjunctiv und optativ ausgedrückt wird;*" *i. e.*, the force of the subjunctive and optative does not depend upon the *κεν* or *ἄν* but the *κεν* or *ἄν* simply adds a more eloquent expression to the force already inherent in the subjunctive or optative themselves. If this be true, it accords excellently with the signification which Osthoff wishes to attach to *κεν*, and we shall then not be surprised if we find *κεν* joining itself freely with any mode and tense.

Thus in Homer we find *κεν* with the future indicative as *Α* 139 *ὁ δέ κεν κεχολώσεται ὅν κεν ἵκωμαι*, which Osthoff would render "*der wird wol zürnen, zu dem ich kommen werde;*" or *Δ* 176 *καί κέ τις ὧδ' ἐρέει Τρωων* "*so wird wol mancher unter den Troern sprechen;*" and a number of similar instances.

The present indicative also occurs, though rarely, as *Ξ* 484 *τῷ καί κέ τις εὔχεται ἀνήρ* "*darum wünscht sich wohl auch mancher.*"

Faesi, in his edition of the Iliad, in commenting upon these and similar passages says that *κεν* with the future and present indicative does not express any doubt or uncertainty, but a calm confidence, equivalent to that expressed by *που, οἶμαι*. *Cf.* his notes on *Ψ* 102, 484. In this sense *κεν* corresponds exactly to the German *wol* in such expression as "*das ist wol*

zwanzig jahre her; ich bin wol zu beneiden," where *wol* is quite equivalent to the Greek κου, οἶμαι, "forsooth, I think, in my opinion."

It is doubtful whether we have any example of the imperfect with κεν, as the reading of β 104 is uncertain. Only one manuscript reads: ἔνθα κεν ἠματίη μὲν ὑφαίνεσκεν μέγαν ἱστόν. The others give ἔνθα καί; but of the aorist indicative we have at least one instance, *viz.* δ 546.

> ἤ γάρ μιν ζωόν γε κιχήσεαι, ἤ κεν Ὀρέστης
> κτεῖνεν ὑποφθάμενος.

Here again we may translate "you will find him alive or (it may be assumed) Orestes has killed him," the κεν being equivalent to *wol*. In German we might translate "*oder es hat ihn wol Orestes getödtet.*"

In German *wol* is used with the perfect indicative with great freedom in popular poetry, *e. g.*,

> "*Es ging ein Müller wol über's Feld.*"
> "*Es zogen drei Burschen wol über den Rhein.*"
> "*Ein Knäblein ging spazieren wol um die Abendstund.*"

That no example of the perfect indicative with κεν in Homer is found, Osthoff regards a matter of chance, to be explained by the rarity of the perfect indicative in the epic or narrative style.

So much for the form and signification in which κεν, κα has attached itself to the primitive perfect to produce the -κα- perfect. Let us now note the successive stages of the process by which the -κα- inflection became established throughout the whole perfect indicative and subsequently throughout the whole perfect system. First let us set clearly before our eyes the original inflection of the perfect indicative active of a Greek verb, such as those among which we know the -κα- perfect to have arisen, *viz.*, long vowel stems. Let us take the stem στᾱ- (Ion., Att. στη-). The early Greek inflection of this perfect (though not the earliest) was probably

Singular.		Dual.	Plural.
*ἕστη	(for *ἕ-στη-α; *cf.* λέ-λοιπα)		ἕσταμεν
*ἕστης	(for *ἕ-στη-ας; *cf.* λέλοιπας)	ἕστατον	ἕστατε
*ἕστη	(for *ἕ-στη-ε; *cf.* λέλοιπε)	ἕστατον	ἕστασιν

The stages of development are as follows:

1. By the union of the κα with the original 1st singular *ἕστη we get ἕστηκα. Further illustrations of this perfect from long vowel stems are:

> δέ-δη-κα (δέω 'bind') Aeschylus, Andocides.
> τέ-θη-κα, later τέ-θεικα, after the analogy of εἶκα.
> δέ-δω-κα.
> *γέ-γνω-κα, later ἔ-γνω-κα.

2. In the second stage we find that the -κα- perfect has extended its inflection from the first singular in -κα- to the second singular in -κας and

the third singular in *-κε(ν)*. In this step it has, of course, simply adopted the regular perfect inflection as already existing in the language and exhibited in such words as *πέποιθα, πέφευγα, ἔρρωγα, etc.* The *-κα* inflection, however, has not yet strayed beyond the limits of the singular. The dual and plural show no traces yet of the *-κα*, as seen in such words as

γέγηκα,	pl.	*γέγαμεν*
βέβηκα,	pl.	*βέβαμεν*
τέτληκα,	pl.	*τέτλαμεν*
τέθνηκα,	pl.	*τέθναμεν*
ἕστηκα,	pl.	*ἕσταμεν*
even *δέ-δω-κα,*	pl.	*ἀπο-δε-δό-ανθι* Cauer[2] 298.

This second stage is characterized further by the formation of new *-κα-* perfects, but only from long vowel stems; and these new formations have, like their models, the *-κα-* inflection only in the singular. This is about the stage represented in the Homeric epics. For out of the hundreds of instances of the *-κα-* perfect in Homer, all formed from long vowel stems, we have only five instances of a plural *-κα-* perfect, *viz:*

ἑστήκασιν	*Δ* 434
κατατεθνήκασιν	*O* 664
πεφύκασιν	*η* 114
τεθαρσήκασιν	*I* 420,687

3. The *-κα-* inflection extends itself throughout the entire indicative, and also throughout the rest of the perfect system, *i. e.*, the subjunctive, optative, infinitive and participle. This stage is represented in general by the post-Homeric Greek, though an incipient tendency of the *-κα-* forms to extend themselves is seen in Homer, in the sporadic occurrence of a few plural indicatives and a few perfect participles.

With this the development of the *-κα-* perfect may be considered complete. Some interesting changes in the Ablaut occurred, which may be left unmentioned.

Osthoff finds in certain Sanskrit forms what he considers a powerful support of his theory of the Greek *-κα-* perfect. These forms are the Sanskrit perfects:

dadâu, dadhâu, papâu, tasthâu.

Osthoff thinks that here we have original perfect forms with the added particle *-u*.

da-dâu is therefore simply *da dâ-u, etc.*, this *-u* being the same particle that we have already noticed as occurring in the Gothic *nimadau, nimaidau.*

Any one familiar with the Sanskrit sandhi-rules will see at once an objection to this theory, since *pa-pâ-u, da-dâ-u, etc.*, ought, according to the laws of Sanskrit phonology, to give not *pa-páu, dadâu but papó da-dó.*

Osthoff, however, maintains that the composition of the root with the particle antedates the historical period of the Indian language and that we have in *da-dâu, etc.*, the legitimate successors of an Indo-European *de-dó-u*. Whitney in his *Sanskrit Grammar* (§ 800 c of the German ed.) cites two forms from the Rig Veda of perfects from *â*-stems in simple *â*, not *-âu*, *viz.: paprâ, jahâ* (*prâ-?, hâ-* "follow"), instead of *paprâu, jahâu*. This would seem to indicate that roots in *-â* originally formed the perfect in *-â*, and if that is so it would be natural to see in the forms in *-âu* traces of an added *-u* as Osthoff does. If now, reasons Osthoff, the Sanskrit employs the particle *-u* in a perfect formation by adding it to the 1st and 3rd singular of long vowel stems, what more natural than that the Greek should do the same with κεν?

Osthoff's theory then, briefly stated, is that the particle κεν in its weak or unaccented form κα, a form actually occurring in several Greek dialects, became added to the original perfect forms of long vowel stems, first to the 1st and 3rd singular, and that it afterwards extended its range over the entire perfect system; and the analogy of the Sanskrit perfects in *-âu* is appealed to, to substantiate this view.

Is this a probable theory? It seems to me that it does have a good deal to commend it to our favorable consideration.

1. As to the amalgation of different words into one word in the individnal Indo-European languages we need have no hesitation. Instances are frequent of the union of an inflected form with a particle, or of two inflected forms with each other, as may be seen, *e. g.*, in the Gothic *liu-ganda-u, nimaida-u* (Greek νέμοιτο), in the French *j'aimer-ai*, Latin *vēneo*, (for *vēnum eo*), *calefacio, fervefacio, etc.*, and, as I incline to believe, also in Sanskrit *dadâu, etc.* As to the form κα, it is only what we should be compelled to assume as the weak form of κεν, even did we not know of its actual existence in several of the Greek dialects. That the form κα therefore should combine with the original perfect is not at all unlikely.

2. As to the exact etymology of κεν (κα) I conceive that that really concerns the main question very slightly. It is immaterial whether κεν be the same as the Sanskrit *kam* or *çâm*, or in fine neither the one nor the other. It is certainly an independent word of the Greek language and as such can unite with an already existing inflectional form to create a new form. If it really be the same as the Sanskrit *çâm* and has gone through the same semasiological development as the German *wol* so much the better, though neither of these facts is necessary to our theory.

3. To my mind it can hardly be fortuitous that we find the origin of the -κα- perfect in Greek in those very stems, which in Sanskrit we are led to look upon as compounded in their perfect formation, with the particle *-u, viz.*, the long vowel stems. To be sure we find this *-u* in the Sanskrit perfect only in the 1st and 3rd singular; yet we must bear in mind that in Greek also the perfect in -κα was for a long time confined to the singular of the indicative, and that practically only in the post-Homeric Greek did it extend its range beyond this.

It should further be borne in mind that the three identical roots which furnish us with the earliest specimens of the Greek -κα- perfect are also Sanskrit roots in -â, which form the perfect in -âu. Thus we have side by side the roots

στᾱ- (Ion., Att. στη-)	*sthâ-*
δω-	*dâ-*
θη-	*dhâ-*

And the perfects

ἕστηκα	*tasthâu*
δέδωκα	*dadâu*
τέθηκα	*dadhâu*
(τέθεικα)	

It would seem as though these possessed some innate tendency to join to themselves a completing element, and if that be so what other element can this be for the Greek than κα, and what can κα be but the particle κεν in its weak form?

4. As to the non-occurrence of κα with the perfect indicative in any historical monuments of the Greek language, we need not feel any surprise, such as Curtius does, in his critique of this theory, in his *Zur Kritik der neuesten Sprachforschung*, p. 152 f. Curtius considers in fact that the non-occurrence of the particle with the perfect indicative is sufficient ground for condemning the whole theory, which he proceeds to do very summarily.

But let us consider a moment. By the very terms of the hypothesis, it must have been at a period considerably prior to the oldest monuments of the Greek language that the particle κα become united with the already existing perfect inflection to form the -κα- perfect. At that time the particles κα, ἄν and very likely many others enjoyed a much freer use and wider application than later, when the language had become more stereotyped. Certainly at the beginning of the historical period of the Greek language κεν and ἄν had become appropriated to certain distinct uses and were confined to them. Not only do we not find either κεν or ἄν with the perfect indicative in Homer, but it is only with the greatest difficulty that we succeed in gathering together a few instances of its use with the present and future indicative. Even if we had discovered one or two instances of it with the perfect indicative it would not have materially favored our theory.

It seems to me, therefore, that Osthoff's theory exhibits an unusually keen perception and fine appreciation of the principles governing linguistic development, and that, while it cannot, any more than Brugmann's, be called a demonstration, yet it is as probable and even more instructive.

HARTMANN'S THEORY.

Hartmann's theory appeared first in *Kuhn's Zeitschrift*, vol. xxviii. p. 284, in a brief article entitled *Wieder einmal das κ- Perfectum*.

Hartmann starts with the declaration that the -κα- perfect could take its

origin only from such stems as possessed a gutturally extended form by the side of the original one. Thus πτώσσω for (*πτωκ-ιω) which points plainly to a stem πτωκ-, as an extension of the stem πτ- (*cf.* πί-πτ-ω), gives the perfect πέπτωκ-α. This πέπτωκα, being associated with πί-πτ-ω as its perfect naturally gave rise to the conception of -ωκα as the perfect suffix, whence arose such forms as ὄχωκα, οἴχωκα, possibly even ἐδήδοκα.

This is intended to serve only as an illustration of the method to be followed in seeking the origin of the -κα- perfect. Hartmann admits that the relation between πτ- and πέπτωκα could only give us -ωκα as a perfect suffix (as seen in ὄχωκα, οἴχωκα), not -κα. He is consequently led to seek further in search of some analogy which shall be more far-reaching in its effects. He thinks he finds this in the relations existing between βάσκω and βέβηκα. He explains βέβηκα as the perfect of βάσκω properly, not of βαίνω, and as arising by proportional analogy. Just as λάσκω, which is a real guttural stem (being for *λακ- σκω, *cf.* ἔ-λακ-ον, aorist), forms its perfect λέληκα, so after the same analogy βάσκω (though not really from a guttural stem) forms the perfect βέβηκα.

After βέβηκα had once come into existence the analogy extended to other presents in -σκω, *e. g.*, θνήσκω, βλώσκω, βιβρώσκω, *etc.*, whence the perfects τέθνηκα, μέμβλωκα, βέβρωκα; then subsequently to other stems.

Such in brief is Hartmann's theory, though his own statement of it is exceedingly unfortunate and obscure. It will be seen that it resembles Brugmann's theory quite closely. I hold it, however, as much less probable than Brugmann's for three reasons.

1. The analogy by which βάσκω is supposed to form its perfect βέβηκα, *viz.*, from the relation existing between λάσκω and λέληκα is not at all plausible. There is no similarity of meaning between the two words which would tend to associate them together in the mind, nor is λάσκω a common word or one which from the frequency of its use would be expected to exercise an influence upon other word-forms.

2. There is no evidence that the form βέβηκα is more recent than λέληκα, as is implied by the terms of Hartmann's theory. Both forms are found in the oldest monuments of the Greek language, but nothing tends to show that λέληκα existed before βέβηκα, so as to serve as the model for the formation of the latter.

3. It is not likely that a formation taking its origin from a present with a *short* vowel, like βάσκω should operate immediately in affecting presents with a *long* vowel as θνήσκω, βλώσκω, βιβρώσκω, *etc.*, while at the same time failing to influence presents with a short vowel, such as βόσκω, φάσκω, *etc.* On the other hand we should expect these short vowel presents to be first affected by the analogy, and the long vowel presents later, if at all.

ON SOME METAMORPHOSED ERUPTIVES IN THE CRYSTALLINE ROCKS OF MARYLAND.

BY WM. H. HOBBS.

Recent studies of the crystalline rocks, while they leave us still in doubt as to the origin and much of the subsequent history of the so-called *fundamental complex* (*Urgeneiss* or *Grundgebirge* of *Germans*), yet have been very successful in explaining satisfactorily many areas of crystalline schistose rocks by the metamorphism of sedimentary layers or eruptive masses. Thus many areas of rocks not to be distinguished in the hand specimen from schists which lie below the lowest fossiliferous horizons, have been shown to be metamorphosed sediments of Silurian, Devonian, or even younger ages. In Norway and in western New England, Silurian beds have been changed to crystalline schists. Schistose Devonian rocks occur in the Ardennes and Taunus. In northern Italy, at Carrara, the Trias is represented by marble and in other localities crystalline schists are assigned to the Cretaceous.

In seeking to analyze more carefully the process and find analogies with other metamorphosing agencies, the attention is directed at once to those processes which take place within the contact-zones of eruptive masses. Careful comparison shows that as concerns mineral decompositions and the atomic and molecular re-arrangements, the two processes yield remarkably similar results. The hydrous minerals generally disappear, certain mineral species disappear and are replaced by other species formed from their constituents, which are more stable under the conditions of the process. The more common metamorphic minerals are mica, garnet, staurolite, epidote, vesuvianite, wollastonite, and certain varieties of pyroxene and hornblende. Analyses *in toto* of the unaltered and metamorphosed phases of the same rock yield identical results, exceptions being noted when tourmaline, topaz, or allied species, in whose formation gaseous material is concerned, have been developed during the process. Mineralogically, then, the process consists in a more or less thorough rearrangement, which may be mainly molecular as in the case of hornblende after augite, but it more frequently involves elaborate chemical decompositions and reactions. The German expression, *Umbildung*, aptly describes this process.

If the agent be sought which affects the transformations, we are directed to a different source in each of the two cases of Contact and Regional

metamorphism. In the first it is without question, heat, while in the second we are forced to believe that heat, if a factor at all, is a very small one, its place being taken by pressure, accompanied by internal movement. Where the rocks show most disturbance in the field, there the microscope reveals the maximum of pseudomorphic change and alteration of texture.

We see then, that much the same effect can be produced at least along two different lines, and from what has been said about the chemical composition of the rock before and after the process, it would not seem to be impossible to produce by metamorphism from a shale and a gabbro, the same resultant rock, provided their analyses *in toto* were the same.

The study of metamorphosed massive rocks has yielded perhaps the most satisfactory results, since the original character is frequently betrayed even after pronounced metamorphic action, by areal or structural relations, or by the remains of rock-textures. The sending of dikes or apophyses into surrounding rocks, the presence of included fragments of them, and the remains of crystal boundaries now existing for some other species known to be secondary, are valuable bits of evidence. In some regions where massive gabbro or diabase occurs in conjunction with hornblende gneisses, it is seen that they pass insensibly into one another, and careful study has shown that the hornblende gneiss is the metamorphosed form of the gabbro. Geologists have further been able to trace the steps of the process by examining the rock from parts of a given area that have been but slightly effected, at localities where most disturbance has taken place, and at intermediate points. It would seem that the feldspars are the most sensitive to disturbance, a wavy extinction between crossed Nicols being noticeable when the other minerals show no effects. If the process is more advanced, a breaking up of this mineral may result, and one of the decompositions to saussurite, epidote or amphibole may be noticed. Pyroxene is altered to amphibole (Uralitization). A breaking up of hornblende crystals takes place with an arrangement of the longer axes of fragments parallel to a plane of schistosity. The details of the process differ somewhat according to the original chemical and mineralogical composition of the rock, the intensity of the matamorphism, and other conditions which we can not analyze.

A region which furnishes an example of the metamorphism of gabbro to hornblende-gneiss is that southwest of the city of Baltimore. The Potomac formation (Juro-Cretaceous) consists in this vicinity of unconsolidated gravels which rest on the crystalline schists and gneisses of the Pre-Cambrian belt, and their included intrusive members. To the west and northwest of the city of Baltimore is a nearly circular area of hypersthene-gabbro and gabbro-diorite, which has become well known through the beautiful studies of Dr. Geo. H. Williams. The results have been published in a bulletin of the U. S. Geological Survey. Professor Williams has shown that the hypersthene-gabbro of that area passes into gabbro-diorite by the alteration of both hypersthene and diallage to horn-

blende. The alteration begins on the surface of the pyroxene and proceeds from there toward the center. From the same hand specimen sections were prepared in which could be seen almost unaltered pyroxene, and the same mineral with wide marginal fringes of hornblende. In the hand specimen the hypersthene-gabbro possesses a bronzy lustre from the preponderance of orthorhombic pyroxene, while the gabbro-diorite is green, owing to the secondary hornblende derived from pyroxene.

An area five miles square immediately southwest of that just described, I have examined in the field and studied by means of microscopic sections and otherwise in the laboratory. The western portion of the area is occupied by the Pre-Cambrian gneisses. The remaining portion of the area contains outcrops of gabbro, gabbro-diorite, true diorites, hornblende gneiss, and intrusive rocks which belong to later periods of eruption. The field study shows that the gabbro forms a continuation of the gabbro area studied by Professor Williams. This part of the gabbro area, however, differs in two respects from that farther north; first, in the greater differentiation of the magma, which here produced true diorites as well as gabbro; and, second, in the greater metamorphic action, which has produced from the gabbro first a gabbro-diorite, and then a hornblende gneiss. The true diorites have gone over to hornblende gneiss by much the same process as the gabbro-diorite. These several modifications are assumed to have formed one and the same magma from the absence of any visible contact between them. The gabbro and diorites have not been found in the same outcrop, but the field evidence is such as to make it very probable that they are differentiations of the same mass. Gabbro, gabbro diorite, and hornblende gneiss on the other hand, can be seen to pass imperceptibly into one another in the vicinity of Ilchester. The microscopic evidence is most confirmatory on this point, slides having been prepared from a sufficient number of specimens to show the steps in the process. To make clear, it will be necessary to give somewhat in detail the characters of the end types, gabbro and hornblende-gneiss, and of the intermediate varieties.

Fig. 1.—Section of gabbro-diorite from Ilchester, Md., showing reactionary rims between feldspar and hornblende. X 50.

The entirely unaffected hypersthene gabbro has not been found within the area studied, but a rock containing both hypersthene and diallage surrounded by marginal fringes of green hornblende, composes a core a few feet in diameter enclosed in gabbro-diorite. This core occurs in the wall of rock formed by the railroad cutting at Ilchester station, and its brown

color makes it apparent in contrast with the green of the surrounding rock. The feldspar of this rock is a basic plagioclase, corresponding closely with bytownite. Between crossed Nicols its strained condition is apparent in the wavy extinction. The hypersthene is strongly pleochroic, and, like the diallage, has the usual characters except for the marginal rim of hornblende.

The gabbro-diorite contains neither hypersthene nor diallage, both having been changed completely to hornblende. This mineral is not generally so fibrous as that of uralitized diabases, but it is a green massive variety in crystals not many times smaller than those of the pyroxene from which they are derived. Not infrequently the central portions contain areas, roughly circular, of a colorless mineral of low refractive index, which is believed to be quartz separated in the alteration process, and indicating that its host is less acid than the original pyroxene. Similar areas occur in the hyperite-diorites of Sweden and in the Baltimore gabbro-diorite. The feldspar is bytownite, but here it shows more marked optical anomalies than in the gabbro. In the more effected specimens, hornblende is developed in needles within the feldspar, being sometimes arranged in bands and indicating, it would seem, lines of weakness. In certain of these specimens a distinct reaction-rim appears between the feldspar and the hornblende. Between crossed Nicols this rim affords high colors like those of epidote. Epidote was found by Dr. Williams to compose reaction-rims in the gabbro-diorite of Mount Hope, and it was at first suspected that these aggregates might be composed largely of epidote. Prof. Rosenbusch suggested to me that the mineral is amphibole in thin scales, the high colors resulting from intercalated films of air. (Fig. 1.)

Fig. 2.—Section of gabbro-diorite from Ilchester, Md., showing ilmenite, rutile and titanomorphite. X 275.

In some specimens of this rock rutile is present as an important accessory constituent, associated with ilmenite, and both are surrounded by wide rims of titanomorphite or sphene. (See Fig. 2.) In a few localties (Ilchester R. R. cut) these minerals can be seen in the hand specimen, where they closely resemble the similar association in the hornblende gneiss of Lampersdorf in Silicia. As soon as the rock takes on the laminated character of a gneiss, the feldspars appear broken down or granulated peripherically into fine mosaics (*Randliche Kataklassstruktur.*) Simultaneously a "fraying out" and splintering of hornblende, and a considerable development of epidote are to be

are to be observed. The splintered fragments of hornblende and the newly-formed minerals become roughly oriented with reference to a plane of schistosity. (See Fig. 3.) Plate I is from a photograph of the wall of hornblende gneiss on the left bank of the Patapsco river opposite Ilchester railroad station. In the same region are found other younger intrusive masses which cut the rocks just described. The most important of these is a porphyritic granite containing allanite-epidote intergrowths, and having dioritic facies resembling the diorites associated with gabbro. Isolated bosses of a non-feldspathic pyroxene rock and a coarse hornblende picrite (Cortlandtite) occur. Further, a coarse pegmatite is especially abundant in the nelghborhood of Ilchester.

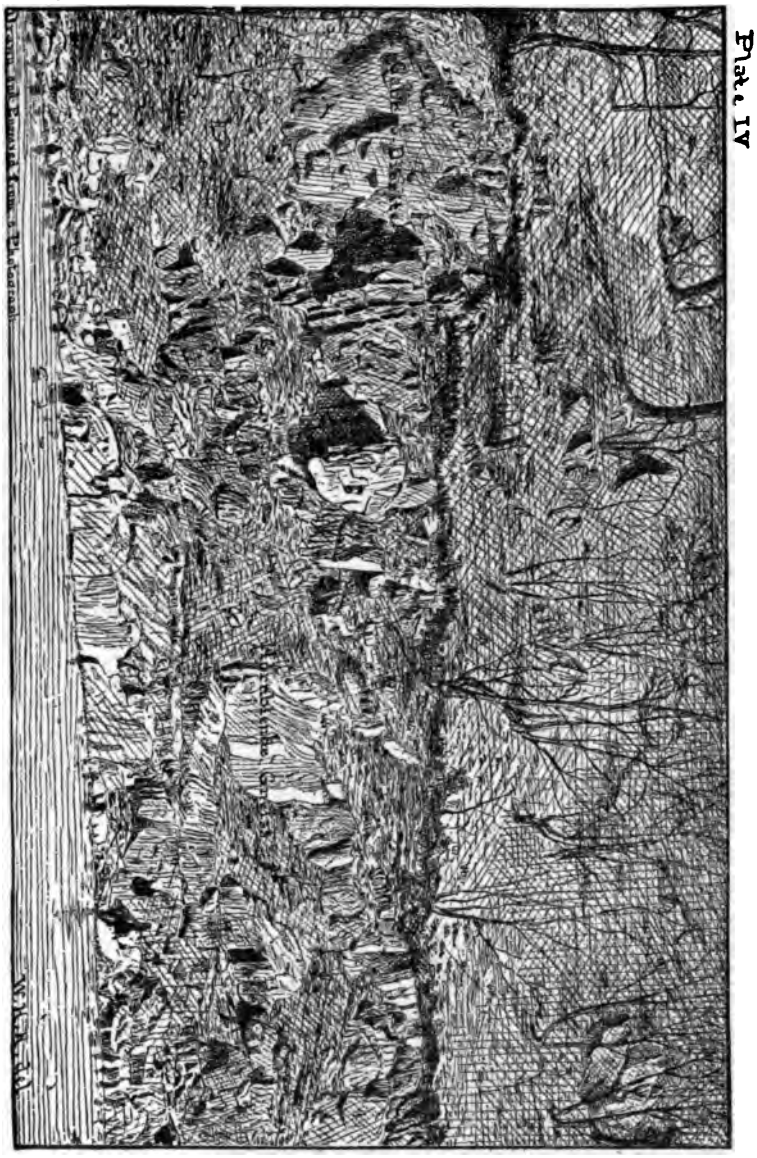
Fig. 3. Section of Hornblende-Gneiss (Metamorphosed hypersthene gabbro) from Thistle Cotton Mills, Ilchester, Md., showing peripheral granulation of feldspar, fraying out of hornblende, and development of epidote with zonal structure. X50.

In the course of a hasty reconnaissance in the Odenwald in Hesse, I was much impressed by the striking resemblance in characters of the rocks of that region and of the one just described. The porphyritic hornblende granites and diorites of the Birkenauerthal resemble more than any others that I have seen the Ilchester granite. In the vicinity of Burg Frankenstein on the Bergstrasse occur gabbros associated with dioritic rocks bearing much resemblance to the gabbro-diorites of Ilchester. The Ilchester Cortlandtite finds its representative in the *Schillerfels* of Schriesheim. The analogy might be carried further to include a pegmatite and a basic pyroxene rock (Wehrlite) from the same general locality in the Odenwald region.

EXPLANATION OF PLATE.

Gabbro-diorite passing into hornblende gneiss. On left bank of Patapsco river, near highway bridge, at Ilchester, Md. The gabbro-diorite is seen on the left, passing by insensible gradations into hornblende gneiss toward the right.

Plate IV


Horizontal Cross Section
Vertical Section
Transverse Section
The Cascade
W. H. B. Del.

NOTES AND A QUERY CONCERNING THE ERICACEAE.

By CHAS. H. CHANDLER, Ripon, Wis.

Plants of the Heath Family are rarely found in regions where the soil is calcareous. The personal search of the writer in his leisure hours for some years, as well as inquiries made of botanists acquainted with the flora of several states, have disclosed no examples of Ericaceae in such regions except such as by their peculiar conditions seem to be exceptions tending to prove the general rule of their absence.

The only vigorous growth found under such conditions has been that of the parasitic Monotropa, reported by several observers; but since its support is thus indirectly obtained from the soil, its growth is not inconsistent with the statement that the Ericaceae will not tolerate compounds of lime.

Rare and feeble specimens of Pyrola rotundifolia are said to have been found in Ripon, Wis., in a region of Trenton limestone. But, as nearly as the two spots in which it was found can now be determined, they were both upon knolls of drift gravel, where the effects of the underlying limestone must have been very slight, if not entirely absent.

A vague account has been received of some one of the smaller species, Vaccinium having been found in or near Waupaca county, in a region of hard water. But here too it may be reasonably suspected that the conditions were like those mentioned in the case of the Pyrola, since the Vaccinium was said to have been found in a region of knolls, and upon the knolls rather than between them.

No other apparent exceptions have been found to the rule that calcareous soils are unsuited to the growth of all members of the Heath Family, and this to a degree which is practically prohibitive.

Several specimens of Kalmia latifolia, upon being carefully transplanted into a soil of weathered limestone and clay in Greene county, Ohio, died at once; and others set in a black vegetable loam filling a long depression in the same soil lingered without any growth for some months and then died

The query whether it is possible for any member of the Ericaceae to grow in a calcareous soil may lead to broader questions which have received very little attention from either writers on agriculture or botany, such as whether the non-adaptability of certain soils to certain plants may not often be due as much to the positive presence of injurious constituent

as to the negative property that certain food elements demanded by the plants are absent; and whether such lines of adaptability do not frequently coincide with generic or family division lines.

NOTE.—After the reading of this paper cases were cited by members present showing real exceptions to the rule suggested. Gaylusacia resinosa is found upon Trenton limestone three miles west of Hanover, Ind., on the high banks of the river. Both Gaylusacia and Vaccinium on hill tops of Lower Magnesian limestone in towns of Troy, Franklin and Spring Green, Sauk county, Wis., and other plants of this order, but the species were not named, in Lincoln county, Ky. In none of these cases, however, did it appear that the drainage from limestone would come to the plants; but still the soil must be calcareous.

ARTIFICIAL KEYS TO THE GENERA AND SPECIES OF MOSSES RECOGNIZED IN LESQUEREUX AND JAMES'S MANUAL OF THE MOSSES OF NORTH AMERICA.—ADDITIONS AND CORRECTIONS.

By CHARLES R. BARNES.

Since the separate publication of the Keys printed on pages 11–81 of this volume, the author has discovered a number of errors, typographical and other. He is also indebted to Mrs. E. G. Britton, Miss C. E. Cummings, Mr. E. A. Rau, Dr. C. W. Swan and Mr. L. S. Cheney for suggestions or corrections. The additions and corrections which have thus accumulated are deemed of sufficient importance for publication.

Page 18, for first three lines under ¶ ¶ ¶, substitute:

Teeth bifid to the common membranous base.
  Leaves subulate to lance-subulate, from a broader base . . . . . **Leptotrichum**, 105. **37.**
  Leaves broader.
    Lid short, conic or beaked . . . . . **Desmatodon**, 110. **38.**
    Lid elongated-conic . . . . . **Trichostomum**, 108. **38.**

Page 23, for line 12, substitute:

Leaf-cells quadrate at basal angles.
  Plants small, capsules about 2mm. long . **Platygyrium**, 307.
  Plants large, capsules about 4mm. long **Cylindrothecium**, 310. **67.**

Page 25, below B. 1, insert:

[**88. cymbifolium** and **papillosum** may be sought here.]

Page 28, for line 15, substitute:

Costa broad above, almost or quite filling point.

Page 30, under **DICRANELLA**, read:

I. *Cells of the exothecium rectangular-quadrate; seta red; costa narrow and well defined below.*

Page 31, line 1, read:

II. *Cells of the exothecium prosenchymatous; seta often yellow; costa usually broad and indistinct below.*

Page 32, set **D. palustre**, 19. opposite line 11 and dele lines 12 and 13. For line 19, substitute:

Papillose at back.
Capsules solitary . . . . . **D. spurium, 21.**
Capsules clustered . . . . . **D. Drummondii, 22.**

Under 2, dele line a.

Page 33, line 13, for b, substitute B.

Page 43, after line 15, insert:

[**G. Pennsylvanica** will be sought here.]

Page 47, for last 3 lines, substitute:

Capsule wholly exserted.
Smooth when dry, defluent into seta . . . . **O. lævigatum, 2.**
Furrowed when dry, abrupt at base . . . . **O. Douglasii, 6.**[1]

Page 48, for line 5 from bottom, substitute:

Capsule furrowed when dry . . . . . **O. Douglasii, 6.**[1]

Page 64, under **NECKERA**, in lines 2 and 4, read:

Plants slender (shoots 1—2 mm. wide), etc.
Plants robust (shoots 3—4 mm. wide), etc.

Page 65, to **Hookeria Sullivantii**, add foot note:

Müller writes (July 18, 1888): "Die *Hookeria Sullivantii* mihi unterscheide ich auch heute noch von *H. lucens* und ebenso von *H. acutifolia* aus Indien." *Fide* Mrs. E. G. Britton.

Page 66, under **THELIA**, for last two lines, substitute:

Usually bi-furcate, teeth long (1:17—20), leaves ciliate **T. asprella, 2.**
Usually 4-furcate, teeth short (1:12), leaves not ciliate **T. Lescurii, 4.**

[1] The position of the stomata of this species is still uncertain, and until it is found again no more definite characterization of it seems possible.

Page 69, under ++ ++, for lines 2, 3 and 4, substitute:

Stem leaves short acuminate, cilia 2, annulus double . **H. scitum, 8.**
Stem leaves long acuminate, cilia 3, annulus simple . **H. gracile, 10.**
Stem leaves long acuminate, cilia 1, annulus 0 . **H. calyptratum, 11.**

Under +- +-, for lines 4 and 5, substitute:

Apical cells of branch leaves round, papillose . **H. delicatulum, 14.**
Perichætial leaves not ciliate, apical cells of branch leaves oblong, with 2—3 papillæ . . . . , **H. recognitum, 13.**

Under b insert as line 6:

Plants minute, leaves entire (but papillæ salient), costate to the middle . . . . . **H. pygmæum, 7.**

Page 70, * * , substitute:

* * *Leaves entire, or denticulate above, plants creeping.*

Page 71, under ¶ ¶ insert, as line 1:

Leaf cells rhombic above, rectangular below **H. occidentale, S. & L.**[1]

Change the co-ordinate choices in this paragraph, lines 6 and 12, so as to read:

Leaf cells alike throughout.
Leaf cells enlarged, rectangular at the basal angles.

Page 73, insert as line 8 from botton:

Leaves broad-ovate, acute, segments split . . **H. hians, 77.**

Page 74, for line 3, substitute:

Deltoid, with long slender points (leaves of branchlets sometimes blunt).

Page 75, for line 8, substitute:

Leaves widest above base, long acuminate.
Leaf cells oblong, parenchymatous . . **H. chrysophyllum, 130.**
Leaf cells fusiform, prosenchymatous . . . **H. riparium, 127.**

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[1] Sull. Icon. Musc. Suppl. 105. pl. 81.—Accidentally omitted from the Manual.

Page 76, for last 10 lines, substitute:

Leaves not falcate.
- Abruptly filiform apiculate, alar cells not conspicuous . . . . . **H. trichophorum, 100.**
- Gradually filiform acuminate, alar cells orange.
  - Plants slender, 2—3 cm. long.
    - Branches erect, leaves serrate . . **H. Muhlenbeckii, 111.**
    - Branches intricate, leaves nearly entire . **H. Fitzgeraldi, 112.**
  - Plants stout, 7—10 cm. long, leaves quite entire **H. stellatum, 131.**
- Acute or short apiculate, alar cells few, large . **H. palustre, 165.**
- Obtuse, entire, alar cells hyaline . . . **H. cuspidatum, 176.**

Page 78, under II, in parenthesis, dele:

and **Brachythecium Thedenii.**

The following typographical errors should also be corrected:

Page 13, line 1, for nothing read noting.
Page 15, line 10 from bottom, for 153 read 152.
Page 22, line 4, for **B** * read **2** *.
Page 53, line 20, for P. Muhlenbeckii read **P. Muhlenbergii.**
Page 60, line 7 from bottom, for A. augustatum read **A. angustatum.**
Page 69, line 16 from bottom, for H. abietiuum read **H. abietinum.**

THE RELATION OF OLD ENGLISH 'REOMIG' TO GOTHIC 'RIMIS.'

By G. H. BALG.

The following discussion is the concluding part of my paper on "The Science of the English Language in the Light of Gothic," read before the Wisconsin Academy of Sciences, Arts and Letters, December 28th, 1888.

A number of Germanic stems in *-us : is*, both concrete and abstract, have been given by Sievers, in his Old English Grammar, by Kluge, in a review of that grammar ('Anglia,' vol. V, part 4), by 'Paul, in Paul and Braune's Beitræge' (vol. IV, p. 415; VI, p. 229), by Kluge, 'Nominale Stammbildungslehre' (§§ 84 and 145), and elsewhere. The above suffix answers to Gr. *ος : ες*, in neuter substantives like *γένος*, gen. *γένους* contracted from *γένεος*, for a more ancient **γένεσος;* and to Lt. *us : er*, in *genus*, gen. *generis*, for **genesis*. The accent fell on the radical syllable, and, therefore, in Germanic the suffixal *s* changed into *z* which appears in Gothic as *s* when assuming the final position, but, by leveling, there occurs *z* for *s*, and *s* for *z*.

The Gothic word *rimis*, 'rest, quietness,' shows *s* in all cases. Its original stem, *rimiz-*, answers to pre-Germanic *remez-*, from root *rem* seen in Gr. *ἠ-ρεμ-ος*, *ἠ-ρεμ-αῖος*, 'quiet,' *ἡ ρεμ-ία* 'rest.' According to the law that pre-Germanic unaccented *e* changed into *i* in Germanic, and pre-Germanic *accented e* became *i* in Germanic, when the following syllable contained *i* (Comp. Gr. *πόδ-ες*, Germanic **fót-iz*, primitive Old English fêt-i, by *i*-umlaut of *ô* and loss of *-z;* later *fête*, Middle English *fêt*, Modern English *feet*), pre Germanic *remez-* first became *remiz-*, and then *rimiz* (=rimis), our Gothic word in question. Furthermore, Germanic unaccented *i* after a short root syllable was first retained as *i* in Old English and afterward weakened to *e*.

According to the above laws of development and decay, Germanic *remiz* (Goth. *rimis*) appeared in Old English as *remi : rimi : rime*.

Now I claim that *rime* is found in Old English *reomig*, 'quiet,' formed by means of the Germanic adjective suffix *-ag-*. The dark vowel of *-ag* changed the *i* of *rime* (the final vowel of which was dropped) into *io*, **rimag* becoming *riomag*, later **riomeg* (by weakening). But there is another Germanic suff., *-ig* (=Goth. *-eig-; -ag-*= Gothic *-ag-*), which was likewise

used to form adjectives from substantives. In Old English *-îg* was first shortened to *-ig*, and in the inflected cases weakened to *-eg*. In consequence of this weakening, the two suffixes *-ag* and *-eg* coincided in the inflected cases, and, by the law of analogy, there occur not only nominative cases with original *-ig*, but also such with *-ig* for *-eg*, from original *-ag*; an example is our Old English adjective **riomig*. A similar case of confusion is that of Old English *io* from *i*, and *eo* from *e*, a fact supported by numerous examples. It is owing to this double confusion that Old English *reomig* stands for **riomeg*; hence, Old English *reomig* is derived from **rime*= Gothic *rimis*.

ARISTOTLE'S PHYSICS (PHYSIKE AKROASIS) REVIEWED.

BY JOHN J. ELMENDORF. S. T. D.,

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An attempt to revivify Aristotle's Physics, when this nineteenth century is drawing to its close, may seem to some an absurd anachronisn. His misstatements of facts have furnished stock quotations to those who would illustrate the ignorance of benighted antiquity. His *a priori* method has been only subject for ridicule, because in this enlightened period there is only one secure path to true scientific knowledge, sc., the slow, but safe road of accurate observation and careful experiment. If the critical observer, from without the sacred precincts, remarks that empirical science manifestly contains *a priori* assumptions which indicate the line, *among* an infinitude of lines, which experiment shall follow, and is stated under the form of concepts which need accurate definition, the reply may be that advanced science is proceeding on the straight and lowly road of "phenomenology," and confines itself to that. The critic might reply, with Aristotle, that there can be no such thing as a science of phenomena, because they must be appearances of some thing, and cannot be thought or described, much less *accounted for*, without some assumption, true or false, respecting that thing. But the dispute would only grow more lively, and the end be far off. The critic will, perhaps, be safer in confining himself to the remark, that so long as the experimenter says, "I see that," no meaning can be attached to the purely phenomenal construction of his words, to-wit.: "A chain of successive (subjective) states called, *I*, is at this moment followed by the subjective state called, *seeing* one of co ordinate phenomena called *that*." Since pure phenomenology appears to be reduced to this, so much the worse for phenomenology.

Logic, pure mathematics, even that despised thing called metaphysics, will have their word in the matter, and claim their place in the large domain called "science."

It is, perhaps, time to call a halt; and after laughing at "high *priori*" roads to science, to consider more seriously whether or not those same *a priori* methods have not some place even in the study of nature, whether or not the analysis of reason's fundamental concepts and necessary judgments is absolutely worthless for scientific ends.

Admitting, provisionally, the absurdities of Aristotle and his school, cheerfully granting the necessity of verification of all deductive inferences, yet I have reason to maintain that that *a priori* road, where every concept is rigidly defined, and primary truths are analyzed, truths absolutely unassailable, has proved suggestive of observations, fruitful in inferences which might have been verified, but which have been very slowly reached, and only as hypotheses, by the empirical route.* The inquiry, it seems to me, is not unpromising: the result may appear in a re examination of Aristotle's Physike Akroasis.

At a first glance, one is impressed by the glaring difference between this treatise and modern works bearing similar titles. It is not merely that Aristotle cites some observations, so-called, which were reported to him, or which he himself noted with very inaccurate observation: for the same thing has happened since his time. Thus one of our chief contemporary authorities in natural science, cites certain facts, so called, which were privately confessed to me, many years ago, to be sheer imposture, and are now publicly so acknowledged. (M. & K. Fox.)

But, setting this aside, one sees in a modern treatise the attempt, at least, to follow a strictly empirical method, and to attain higher and higher generalizations by careful inductions. In the Physike Akroasis the aim is to clear up those primary concepts which underlie all physical investigations, and to make strict logical deduction from certain primary principles, however those may have been obtained, which have the most absolute and intuitive certainty.

This difference is of course largely due to the fact that Aristotle is aiming at the philosophy of physics; to secure clear concepts and precise definitions, to determine (I. 1.) the principles, causes and elements concerned in nature.

Aristotle first (I. 1) indicates his method, which is to proceed from what is more familiar as coming under the observation of the senses, to what is more fundamental, to elements, causes and principles. I suppose that we must not call this "Baconian induction," but rather analysis. That which is primarily given to us in knowledge is complex; we analyze it, using also logical induction in order to reach remoter, but higher principles. Verification would of course supplement this method, but our author makes very imperfect use of that.

Physics, in its widest sense, embraces all the sciences of nature. What

Grove, in the preface to his "Correlation, etc.," claims what is expressed by his title as the latest and grandest discovery in physics. We will not dispute his assertion, if he means experimental physics. But inasmuch as Aristotle maintains that all change in nature (and nature is that world of beings whose characteristic mark is change, II, 1; III, 1,) is reducible to local motion, and gives clear demonstration of his proposition, Grove's assertion, taken in its widest sense, seems hardly warranted by the facts. On the contrary, the *a priori* method ought to have pointed out, in this case as in others, the road for experiment, by giving anticipations from something more than "scientific imagination" of the results which might be expected.

is nature? A collective name for those things, together with their causes, etc., which have in themselves a principle of motion or change (kinesis). (II. 1.) It is necessary, then, to have clear concepts of matter, form, cause, change, including local motion, time and place or space, with their correlated ideas, and this is the aim of the treatise now before us.

(I. 6, 7). Two principles at least, perhaps three, are necessary to explain nature as it is known by us, viz., a passive matter, and an active force, manifested in contrary phenomena; (attraction and repulsion, heat and cold, etc.)

Motion, kinesis, taken in the widest sense, is the (continuous) transition from a potential state to an actual state. It is either a change of quantity, or of quality, or of place. But the three are reducible to one, viz., local motion. (VIII, 1.) If to these we add the change from potential to actual being in generation, and its contrary, decay (phthora) we shall have the whole sphere of changes perceived in nature.

II. 2. Applied mathematics consider the purely intelligible and unchangeable element which is found in nature, underlying all its changes.

II. 3. We account for any of those changes which we perceive in nature, when we assign their causes. But the word cause is very ambiguous, and needs definition. All uses of the word are reducible to four: (1). The *material* of the thing which comes into being may be called its cause, (condition), as marble of the statue; (2). The *form* or pattern, as the idea of an oak is that towards which the acorn develops; (3). The efficient cause or originator of the change which may itself be a changeable antecedent; (4). The *end*, or final cause, or reason why. Why does one take exercise? The cause is not fully given, if we name the man, describe the exercise and account for muscular contraction; we add (II, 3), another cause; sc., the exercise is for the sake of health.

In discussing cause, also, we must not overlook the fact (II, 7) that two very different principles are requisite in explaining nature, sc., the sensible antecedents, and the intelligible principle which is not physical nor subject to change. Nature requires for its explication the supernatural.

II. 8. The discussion of final causes is of such interest in connection with modern physics, and especially with reference to recent questions in Natural history, that I may perhaps be allowed to present it in condensed paraphrase. Why would it not be sufficient explanation of the expansion of water cooled down to 40 degrees of Fahrenheit, if we could, as we cannot, assign its physical antecedents? But our mind recognizes a relation to the good of the world, an order and connection of things. And we must assign chance, spontaneous action, or design, in accounting for that order, if we assign any cause for it. (Chance, here, does not mean the entire absence of law, but a law which does not enter into the series of events in question.)

By chance results may be obtained, indeed, as, when our guest came for other reasons but took a bath at our house, we say that by chance he took a

bath. But neither chance nor spontaneous action will account for the invariable series in nature's work which I have illustrated in the expansion of cooling water with its effects; therefore, final cause must be assumed. I am not considering the value of this argument; I only note it as the first.

Secondly, each thing in nature acts as it is adapted by nature to act; and as it acts, so it is adapted by nature. It acts for some end, therefore it was naturally produced for that end. If a house were among natural things it would be constituted as it now is by art. And if natural things could be produced by art, it would constitute them and adapt them as they now are. Art sometimes imitates nature; sometimes attempts what nature does not; but in both cases for some end. The argument, then from art's having an end to final cause in nature is valid; for the relation of prior to posterior is the same in both.

Thirdly, we have no warrant for imputing conscious art or deliberation, to insects or to vegetables; yet there is an end, a form towards which these work.

Here we note an objection, that if nature seeks an end, she does not always reach it. But the same thing is true of art, wherein all admit the existence of final cause. This principle does not exclude the principle of necessary conditions, which are found in the matter by which all things that are produced are conditioned. In these we must find the cause of failure. The end of a saw is to cut wood, but iron is the necessary matter, and may be the cause of failure. So nature requires the matter, but the end is found in the form, the idea (eidos). If the end is to be reached, the antecedent conditions must also exist; if these latter do not exist, then the former cannot exist.

Without criticizing these arguments, I note the wide divergence of method from the empirical. But as the latter can only discover antecedent conditions existing in time, we need not allow it to interfere with our estimate of Aristotle's analysis of final cause and his attempted demonstration.

Its value seems to consist largely in its fixing attention on the necessity of a rational explanation of nature. For who explains a watch by merely stating its materials, and the physical antecedents of its motions? The plan, the adaptation of part to part, the end accomplished, are still more essential. So in nature. Who explains a woodpecker's tongue, if he describes its anatomy and mechanism, and speculates concerning its origin, but leaves out its relations to the bird and the conditions of its life?

III. 6. The infinite is a physical concept which requires examination and definition. Physics treat of body, that which has dimensions; and whether it be known sensibly, or regarded in thought, it is necessarily limited, finite. Potentially it exists in thought as indefinite, (apeiron) that from which something can always be taken away, which can be always further divided, to which something of the same kind can always be added. Distinguish, therefore, the perfect, the completed whole, (teleion) which as such, admits of no addition or subtraction.

I pass over the proofs that the universe as a whole is finite in magnitude. In the Fourth Book we find the well known analysis of place as a relation existing between corporeal things, the relation of some actual finite body to its container. The universe, as a whole is therefore not in place. (III. 5.)

IV. 8. What then, do we mean by space? It is merely the indefinite (apeiron) enlargement of the same idea, applied to the potential, not actual, extension of bodies with their three dimensions. In other words, space is no actualized entity, but the indefinite thought whose actuality is *place* as a relation in actual bodies. I do not see that in this we have made any advance from our author. Physical science can tell us whether we need anything more.

IV. 8. Aristotle clearly sees and points out the relations of the problem of the existence of a *vacuum* to this question of space. and denies its existence. Vacuum is unintelligible, it involves contradiction in thought; it contradicts experience.

From this denial of a vacuum follows a mechanical theory of motion, (kinesis) which Aristotle intimates, but does not follow out, neither was any man then competent to do so.

IV. 10. Motion and time are co-eval. There never was a time in which motion did not exist. Which brings us to a physical conception, as fundamental as it is thoroughly established, and I believe, as fruitful as any in Aristotle's physics. What is time? He proves that it is not an independent entity. It is not change, which is particular, found in this or that.

IV. 10. It is not motion, which is faster or slower; predicates which are not applicable to time. And yet it requires motion; i. e., change; and all things which are immoveable, unchangeable, are not in time. Time is continuous; it is limited by what we call "now;" which is like a moving point describing a line.

So we reach our definition; "Time is the number of motion (change) in respect of prior and posterior." This, of course, implies an intelligence to do the numbering. In a purely material universe there would be no such thing as time. (It may seem to us otherwise; but we put ourselves there to do the uumbering.)

IV. 11. Time is continuous. not an aggregate of instants or nows.

IV. 12. A very plain deduction is that time is either finite, actually, or indefinite, potentially. But it can never be perfect (teleion) or what I should call the proper infinite. When limited by two nows, like two points, e. g., one past and the other that moving point which we call the present, time is finite; disregarding either of the nows, we get the potentially infinite (apeiron) in duration.

IV. 12. Things which are not in time (and such things there are), neither move nor rest. For rest is the privation of motion, and is numerable in the same way. Those beings only are in time which are subject to motion, to change.

IV. 14. Is time such a relation that it would not exist if there were no mind to number continuous change and refer it to some measure? That seems to be necessary deduction from our definition of time.

VI. 1. Time, like every other continuous quantity, cannot consist of indivisible units, any more than a line can consist of successive points.

VI. 6. All changes, like time their number, are, potentially, divisible *ad infinitum.* From this is deduced the very suggestive principle, that no change or motion can possibly be instantaneous.

In Aristotle's De Sens, Chapt. VI, he applies this principle to show the progressive motion of light.

VII. 1. Wherever there is change, or motion, there must be an antecedent, efficient cause, which itself may be something moved or changed. And so we may make a regress indefinitely; but such a series cannot be infinite.

I do not propose to follow the metaphysical proof of this proposition, but only to note the result, viz., that in physics a first moving cause which is not itself subject to change must, according to principles of reason, be assumed to exist. We shall not reach that first cause, perhaps, by regress through the chain of changes; for these are discovered by the senses; but this first cause is not so discoverable, but is an intelligible principle, necessary in accounting for change, and known with absolute certainty to exist.

VIII. 1. Motion, change, cannot be annihilated. Nature is orderly, subject to law, and the law of continuity of force carries on successive changes in the indefinite extension of time.

VIII. 5. Let us consider further the prime mover. It may indeed, act hrough many media, just as a man may impel a stone through the media of his cane, his hand, etc.; but it is impossible to recede in such a chain through an absolute infinity of links. The first mover, then, is self-moved. It does not constitute one of the chain of links; for those are sensible, the prime mover is purely intelligible. It is itself immutable. Everything which is mutable, is also divisible. But the prime mover is one and indivisible.

VIII. 6. It never changes, but the things which are moved change their relations to it, as it does to them. Here I observe, in passing, that the changed relations of Deity to the world of finite beings, according to this principle, are based on changes in the things which belong to time.

This prime mover is eternal. For motion has neither beginning nor end. It has absolute unity. There may, indeed, be many motors which are immutable; but if they come into being, or cease to be, there must be a cause of that, as of any other change. Thus, we are carried back again to the eternal, primal mover. All change is, in ultimate analysis, reducible to one continuous motion. Therefore the first cause is one only. All living things may be called self moved; but they are also changeable and conditioned by external things.

Concluding this too brief review of Aristotle's fundamental physical principles, I will try to state what laws of nature now empirically stab-

lished, he rationally deduces from first principles of reason, by aid of his accurately defined concepts.

1. All change is reducible to local motion.

2. Energy is an unchangeable quantum, enduring through all transmutations. Motion is never destroyed.

3. All indefinitely continuous motion (local) is in curved lines.

4. Light, and, by parity of reasoning, all changes of condition in matter, transmitted through space, are not instantaneous, but require time for their transmission.

THE DEFECTIVE CLASSES.

By A. O. WRIGHT,

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The defective classes form a series of small but very troublesome tumors upon the body politic. For various reasons, ranging all the way from the imperative need of protection to society up to those humane influences for which our century is distinguished, these classes have fallen under the more or less effective guardianship of government in all civilized countries. Private effort is also doing much to palliate or to prevent the evils which the defective classes bring on themselves and upon society at large. And still there is everywhere an apparent, if not a real increase in the number of these classes and in their ratio to the total population. It is claimed that this increase is in many cases caused by the very efforts which are made to care for them, and it is at least certain that these efforts bring to light many cases of evil which would have been hidden, and preserve many miserable lives which would have been allowed to perish in former days. In other cases it is claimed that the complex conditions of modern society favor the increase of these classes. At any rate the subject deserves attention and study by the philanthrophist as well as by the statesman, by the student as well as by the man of affairs.

It seems to me that the following classification of the defective classes, which is original with me, is more philosophical than any other I have seen and also as good for practical purposes as any other. This classification depends upon the three divisions of the mental faculties which are generally accepted by psychologists. Insanity and idiocy are different forms of defective intellect. Crime and vice are caused by defect of the emotions or passions. And pauperism is caused by defect of the will. Blindness and deafmutism are defects of the senses requiring special forms of education, but are not defects of the mind any more than the loss of an arm or a leg. Blind or deaf and dumb people properly educated are not a burden or a danger to society as are criminals, insane persons or paupers. Their defects are physical not mental, and they should not be classed with persons who have these mental defects.

The above classification has the advantage of starting from the center instead of from the circumference. "The mind is the measure of the man" and it is the abnormal and defective mind which produces the mischief rather than the physical disability or the social conditions. Doubt-

less these have their influence, but it is a more remote influence. The immediate cause is in the mind, and the cure, if there is to be a cure, must be addressed to the mind either directly by argument and influence or indirectly by changing the conditions surrounding the subject, so as to change his motives. Anything which fosters abnormal and ill regulated thoughts or passions or which weakens the control of reason, conscience and will over the mind tends to produce insanity, crime and pauperism. Everything which aids self-control reduces the tendency to these abnormalities.

I am speaking now of these classes as a whole and not here taking account of the exceptions to be found in them. I know a man who was a good average man in every respect, but who by a fall upon his head from a load of hay, was made insane, deaf and dumb and blind, all at once, and who is still thus triply afflicted, but is otherwise healthy. In his case the insanity was a pure accident. The state of Georgia severely punished the missionaries who undertook to civilize and christianize the Cherokee Indians contrary to the laws of the commonwealth. They were criminals in one sense, as violators of human law, but no one will attempt to class them as criminal in anything more than a technical sense. I once found an old man of good character and standing in the community in a poorhouse. He had given his farm to his son on condition of his son's caring for him in his old age. The father was tortured with chronic rheumatism and was therefore some trouble to care for. The son sold the farm and moved out of the state, leaving his poor crippled old father to die in the poorhouse. The father was an accidental pauper and could not fairly be included in the list of voluntary paupers. But such cases as these are exceptions, and the rule is as I have stated it.

The distribution of the defective classes by nationality, education, wealth, age, sex, occupation and the like, is interesting from a scientific point of view and important from a practical standpoint. A study of the distribution of insanity, crime and pauperism, may reveal the conditions which create or foster them. And as society has more or less control over social conditions, it may become possible to heal some of these ulcers on the body politic, if we know where they are and what irritant produced them. But please notice that I say may, not shall. The small success of all effort in the past toward curing these evils, ought to make social reformers modest.

First the question of sex. Men and women are about equally afflicted with insanity. Massachusetts has more women than men insane, because it has more women than men in the total population. Wisconsin has more men insane than women, because we have a preponderance of the male sex. Either the causes are the same in men and women, which produce insanity, or they are equivalent. Heredity, worry, over-work, under feeding, sickness and the weaknesses of old age affect women and men equally, and the

perils of childbirth and of loneliness for solitary farmers' wives are about equal to the dangers from accident and the vices to which men are exposed.

But crime and pauperism are liabilities of men much more than of women. There are generally about forty times as many men as women in our state's prison and in our jails and houses of correction. The disproportion is not quite so great in some other states and is still less in European countries. In Europe there is no sentimental pity for a woman on account of her sex. In this state a few years ago, a farmer was murdered by his wife and the hired man. The hired man is now in state's prison, while the more guilty woman is free. But even in Europe the proportion of men to women is perhaps ten to one. Women do not commit crime as readily as men do; it may be from principle; it may be from cowardice; it may be from lack of temptation.

And women do not become paupers as readily as men. In getting out door relief, it is true, women are a little ahead of men, but that is because it is easier for a woman to get poor relief than for a man. And in fact, where outdoor relief is laxly administered, though it is the women who usually apply for it, there are often lazy men behind them sending them for it or else drinking up all their earnings in the comfortable consciousness that the public will support their families. One case I heard of in this state, where a man spent all his week's wages every Saturday night and Sunday, at a certain saloon, whose proprietor was the officer who gave public money to support the wife and family. That man was the real pauper, not his wife. So that even in outdoor relief, it is probable that the men have a good share of the pauperism. And in the poorhouse, as I said, there are thrice as many men as women.

Second, as to age. About an equal number of each sex are born idiots and remain so all their lives, so that the question of age in idiocy need not be taken into account, except that idiots are not long lived. But insanity is a defect of mature years. Out of thousands of insane whom I have seen, I only remember two insane children. Going through an insane asylum, you are struck with the general age of the patients in contrast with the youth of the attendants. This, of course, is partly caused by the fact that insanity is not very curable. Only about one-fourth of the insane recover, a few die, and the rest end their days as chronic insane. But it is also caused by the fact that most insane are middle aged, or elderly before they become insane.

Crime is rarely committed by little children, and when committed, is excused by the law or by the judges and jury. The absurdity of hanging a boy for murder or sending him to state's prison for life for burglary, both of which have been actually done in the south recently, is not allowed in any northern state. But every visitor to a jail or state prison must notice the comparative youthfulness of the prisoners. The average age of the convicts in state's prison is 27. Or, to put it in another way, the majority

of convicts in state's prison are under 25. The difference between 27 and 25 is accounted for by the difference between an average and a majority.

The direct opposite of this is the case with pauperism. The majority of paupers are over 50 years old. Criminals are mostly young men. Paupers are mostly old men and old women. Youth is the age of passion, and perverted passions lead to crime. The author of the Jukes Family, the best sociological study ever made, says that among the descendants of Margaret, the "mother of criminals," it is very noticeable that in youth they were prostitutes and criminals, and in age, beggars and paupers. The same perverted instincts which led them to prey upon the community, took the direction of crime in the time of strength and of pauperism in the time of weakness.

The question of tramps comes in here. A tramp is a person determined to live without work, and who therefore is compelled to wander from place to place in order to do so. No individual, or society, or institution, or community, will support an able-bodied loafer in idleness any length of time. But many will give a little money or bread out of mistaken sympathy to a stranger, or as the easiest way to get rid of an annoyance. I have seen some thousand tramps, and with very few exceptions they were young men, I have seen two or three men fifty or sixty years old, and I have seen two or three women tramps. But I have seen hundreds of young men under twenty-one, and thousands under thirty, healthy able-bodied men. Among them were a few who were ready for robbery, burglary or rape, if a good opportunity offered. And in the judgment of skilled officers, there are some murderers and other criminals hiding among the tramps. But the mass of the tramps prefer to prey on society by beggary, rather than by crime. If they were bolder they would be criminals. What becomes of the old tramps? I do not believe that many of them live to be old. They are killed on the railroads or die of exposure. Many of them tire of tramping and get back to work again. Some drop into crime and get into prison, and are in some cases reformed by the steady discipline of prison life. One tramp told me that he got the opium habit through the toothache, and was broken of it by being sent to state prison for burglary. Other tramps break down and die in poor houses or insane asylums. We probably have a hundred tramps in our insane asylums in this state, and about as many in our poor houses. This is an enormous proportion to be furnished by from 500 to 1,000 tramps, the probable number who are in our state at any given time.

The question of education is often stated as if education favored insanity and opposed crime and pauperism. As a fact, I do not think that education has so great an influence either way, as many seem to think. We were told half a century ago that it was cheaper to build school houses than jails and poorhouses. We have dotted the country over with schoolhouses, and we find that jails and poorhouses are just as necessary as ever. But some one may say that this is because there is no effective compulsory

education and because we have an unusual number of ignorant foreigners coming to our shores. But this is sufficiently answered by looking at Germany, with its homogeneous population and compulsory education and compulsory religious, as well as secular education, at that. In Germany, crime and pauperism and insanity are increasing as they are with us. Criminals, paupers and insane, all average a little below the rest of the community in education. There are, of course, exceptions. In the case of the insane and of criminals we can all of us point to conspicuous exceptions. I know a few cases of educated paupers, but very few, because their relations or friends care for them and do not let them go to the poorhouse. Inspecting a poorhouse a while ago I found in one of the rooms a book which had been given as a prize for scholarship in a famous New England academy. The owner had been district attorney of the county, and was now in the poorhouse through liquor. All efforts to reform him had proved in vain. But the fact remains that the average of the defective classes is of a lower intellectual grade than the average of the community. Their smaller knowledge and less natural ability makes them break down into insanity more easily and easier drift into crime or pauperism.

The best statistics of criminals have been kept for over half a century by the Eastern Pennsylvania penitentiary. The results of these statistics seem to show that idleness rather than ignorance is the mother of crime. An investigation, which I made a few years ago by personal inquiries from poorhouse to poorhouse in Wisconsin satisfied me that about one-third of the paupers are made so by idleness, one-third by liquor and one-third by all other causes combined. In my judgment the idleness which makes truants from school and therefore poor scholars, leads to crime or pauperism in many cases, and in those cases it is not ignorance which is the cause of crime, but idleness which is the cause of both ignorance and crime.

The question of social standing is not of as great importance in this democratic country as in Europe. Paupers of course do not come from the wealthy or the middle classes. Many of the laboring classes do drop into pauperism through misfortune or vice. But many of the paupers are not even of the laboring class, but come from the outcasts of society. The same is the case with the criminals. They do not come very largely from the wealthy or middle classes. Some of them come from the laboring classes, but they are very largely from the outcasts of society. To some extent this holds good with insanity, but only to a small degree. The insane are found in all classes in considerable numbers, but the laboring class furnishes more than its share of insane, and the outcasts an immense proportion to their total number. Criminals and paupers frequently become insane, I should say, ten times as many as from the same number of average humanity.

The advantages and disadvantages of city life have often been talked of.

Many people suppose that the excitement and strain of city life conduces to insanity. Others say that the loneliness of country life has the same effect. An English physician has taken the pains to tabulate the statistics of insanity for the city of London for forty years and for several purely agricultural counties in the south of England with about the same population for the same period of time, and finds that there is no difference between city and country in the amount of insanity. But for crime, all statistics show clearly that crime is concentrated in the cities, which are the refuge of the criminal classes and the nurseries of young criminals in the neglected street children. Pauperism is greater in the city than in the country, though this may arise from the corrupt municipal governments encouraging pauperism to win votes.

Now I come to some very curious results of the United States of 1880. According to the figures of the census, insanity is about twice as prevalent among foreigners as among native whites, and about twice as prevalent among native whites as among negroes. In round numbers one in a thousand of the negroes of the United States are insane, one in five hundred of the native whites, and one in two hundred and fifty of the foreigners. There has been a great deal of nonsense written upon this by learned men about foreign governments shipping their insane to us to take care of. The fact is that the ordinary immigrants are healthy young people, with less insanity than the average, and that comparatively few cases of insanity are shipped over here, and that in recent years a strict watch is kept at the ports against the shipment of any of the defective classes to this country. One observation will prick this bubble. In the census the children of foreigners born here are counted as natives, properly enough; but by taking away from the foreign population most of the children and adding them to the native population, it makes an unfair basis on which to estimate the proportion of insanity, as children do not become insane. The proper basis would be what is the proportion of foreign born insane to the adult foreign population, and of native insane to the adult native population. On this basis there is still a slight disproportion of the foreign and native insane, but not more than can be accounted for by the comparative ignorance and poverty of the mass of the foreigners who come here and the trials they have to meet in adapting themselves to the conditions of life in a strange land. But why are negroes so much less insane than white people? I do not pretend to say. Perhaps it may be on account of their easy, happy dispositions, which makes them less thrifty than the whites, but also less liable to bring themselves into insanity. Dr. Bryce, of the Alabama State hospital, says that insanity since the war is rapidly increasing among the negroes.

There is a greater proportion of crime and pauperism among foreigners than among natives, probably because of their greater ignorance and poverty, and because they have been accustomed to rely upon a paternal government and do not get accustomed to the freedom of America. The

greater tendencies to pauperism I ascribe to the fact that in most European countries the laboring class is on the verge of pauperism and is continually being pushed over into it by sickness or old age. In England two per cent. of the population are paupers and a large part of the agricultural laborers end their days in the workhouse, for the reason that they barely get a living when able to work and therefore cannot save anything for old age. The paupers in this country are a great deal less than half of one per cent. of the population. Where the laboring classes are brought up to expect to end their days in the poorhouse, it is not wonderful that in coming to this country they seek relief easier than the natives do.

Negroes furnish a larger proportion of crime and a smaller proportion of pauperism than the waites. As the negroes are mostly massed in the southern states, we may look at the condition of society there for part of the explanation of this. Negroes get little sympathy from whites in the south and consequently do not easily get into poorhouses, but do easily get into prison. Negroes do not consider petty theiving very wrong, having learned that during slavery times. A negro will not starve as long as there are smoke houses and chicken coops in the neighborhood, and the climate does not require much in the way of houses, clothing or fuel. But the penitentiaries are filled with chicken thieves. Alabama has three large penitentiaries and Wisconsin one small one, the population being nearly the same.

The effects of climate have not been much considered. But I believe it will be found that warm climates do not have so great a proportion of insanity as cold climates. It is certain that in Europe, Greece has a much less proportion of insanity than Norway. In this country there is less insanity in the south than in the north in proportion to population. A part of this is due to the negroes in the south having a small proportion of insanity, and the foreigners in the north having a large proportion. But it is possible that climate has also something to do with it. I cannot discover that climate has anything to do with crime. Pauperism is increased in cold climates by the greater difficulty of getting a bare subsistence.

Much has been said about the rapid increase of the defective classes, especially of the insane. Statistics show this both in Europe and America. But statistics of the mere numbers of insane at any given time are very deceptive. The greater humanity with which the insane are treated now than a hundred or even twenty-five years ago has preserved their lives and thereby caused an accumulation of the insane. This greatly increases the numbers who are alive at any given time, but does not show that any more persons become insane in any one year than ever. Careful statistics have been kept in England with reference to the latter point and it is found that there was an increase in the proportion of commitments to the total population up to a recent time, but that it now seems to have reached its highest point and become stationary. It is believed that the increase in the commitments was caused partly by the discovery and placing in insti-

tutions of cases that would otherwise have been hidden at home and partly by calling things insanity which formerly would have been called by some other name — such as senile dementia, epilepsy eccentricity or primary dementia. I believe that these statistics show that insanity is not now increasing faster in England than the population.

In the United States insanity is obviously increasing very rapidly. In ten years in Wisconsin the insane under public care have increased from about 1,700 to about 3,000. This is partly due to the causes discussed above. But it is also due to another fact, to which I was the first to call attention, now generally accepted, that the ratio of insanity to the population is much greater in the older states than in the newer ones and in the older counties of Wisconsin than in the newer ones.

In 1860 there were only 200 or 300 insane in the state. In 1880 there were 2,200 including those at home. And now there are probably 3,300 including those at home. The pioneers of Wisconsin were healthy young people, who left their insane behind them. It has taken two generations to reach the amount of insanity we now have. But if we had the proportion of insanity to the population which Massachusetts now has, we should have nearly twice the number of insane we now have. We may expect to keep on with our increase till we reach the proportion of Massachusetts and of England. Already some of the older counties in Wisconsin are approaching that proportion, while those in the north have only the ratio of our far western states and territories.

The rapid increase of crime in this country is doubtless an incident of the rapid growth of city population. But probably the more careful administration of the laws has increased the number of prisoners, while the system of reformatories for boys and girls and all the good influences of christian civilization have been resisting the increase of crime. It is noteworthy that a better prison system in England than we have in this country, joined to the private reformatory work of all kinds, has brought the increase of crime to a stop, and that there is absolutely less crime in Great Britain now than there was fifteen years ago notwithstanding the increase of population.

It is fair to call attention to the fact that the only reliable statistics of crime are from the state prisons, partly for the reason that jails and police stations do not always keep accurate registers, and for the more important reason that officers make petty crimes appear to be less or more at their pleasure. For the sake of fees or to get a reputation for efficiency officers and magistrates often largely swell the number of prisoners by "running in" tramps and drunks to suit their own notions.

The same causes have made an increase of pauperism in this country — the growth of cities and the foolish or corrupt use of public money in aiding undeserving applicants for poor relief.

To a considerable extent these three defective classes link into one another. It is hard to say whether a tramp is a pauper or a criminal.

Many criminals may be called insane and some are when they have money or friends to help them, and some insane have criminal tendencies. A very large per cent. of criminals become insane in prison or afterward. A considerable number of paupers become insane. The children of the one class pass easily into the other class. Street children who are the children of misfortune are easily drawn into crime. Here and there in our country, and in every other one are knots of defective classes all tangled up together, families closely related furnishing a whole population of criminals, paupers, idiots and lunatics among themselves. Such were the family in Ulster county, N. Y., called by Dr. Dugdale the Jukes family to disguise their real name. Such is the "Tribe of Ishmael" recently described by Rev. O. C. McCulloch in Indianapolis. The interchangeability of these defects is very clearly shown in these cases. Another noteworthy thing is the general physical weakness of these hereditary defectives, running easily into consumption and similar diseases. Even in good families with a hereditary taint of insanity it is noticable that it is interchangeable with consumption. One generation or one brother or sister has consumption, another has insanity. Or the same person has insanity but recovers of insanity to die of consumption.

What are we now doing with the defective classes. With some exceptions all civilized nations are pursuing the following lines of policy. Pauperism is relieved and discouraged. The treatment fluctuates between the extremes of lavish relief and stringent discouragement, but is generally a compromise between these two extremes. Insanity is cured if possible, if not, it is usually protected in institutions of some sort. Crime is punished in prisons and prevented in reformatories. These methods express the average wisdom of the present generation, which is far in advance of what has previously been done for the defective classes. It does not follow that this is the best that can possibly be done for them. In fact here and there experiments are in progress which I believe represent not the average wisdom but the best wisdom of our times. Here and there private societies have taken up the work of eradicating pauperism, not by relief, which often encourages it, nor by merely repressive measures, but by carrying out the motto of the charity organization societies, "Not alms, but a friend." And Rev. J. H. Crooker, of Madison, has recently shown by a remarkable historical investigation that this is not a new discovery, but is a century old, when it was more fully applied to public poor relief than it has since been. The methods of reforming criminals and these of reducing crime have been discovered and applied in the British Isles, while in America they have been only so applied in a few places. The methods of treating the insane have been growing milder and more humane in Europe and America within a few years. In my judgment the State Hospital of Alabama and the county asylums for the chronic insane of Wisconsin, mark the highest point yet reached in the direction of liberty for the insane. At the rate of progress which we are now making, it will take a genera-

tion for the average American treatment of the defective classes to reach the standard set for pauperism by the charity organization societies, for crime by Elmira and Concord, and for insanity by the Wisconsin system of care for the chronic insane.

Our measures of treatment of the defective classes sometimes increase the very evil we meant to cure. Poor relief, instead of relieving pauperism, very often increases it. Insane asylums seem to increase the number of insane, prisons of criminals. This, however, is not a necessity of the cure, but only an incidental evil, which needs to be guarded against. We must also allow that our humane methods of treatment, in addition to the good effects which they have, do also tend to increase the number of defective classes, by prolonging their lives and by making their lot a more desirable one. I have already mentioned the accumulation of insanity by the mere prolongation of life in the insane in civilized countries. It is still a question whether this does not sufficiently account for the greater number of insane in civilized over savage countries.

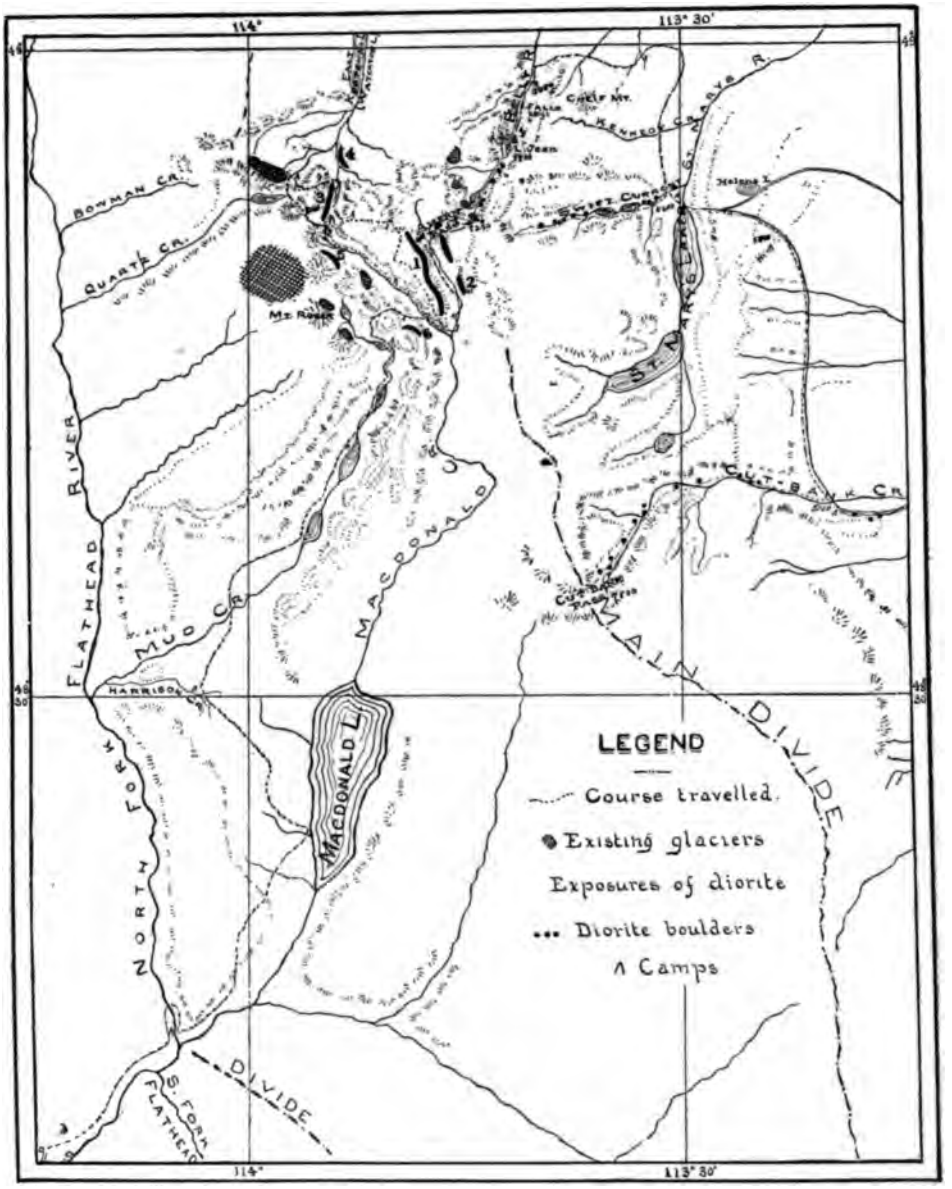
Where the insane are killed as witches or executed as criminals or killed by private vengeance or malice or allowed to die by neglect, and where only the robust can survive the hardships and perils of life in any case, it is not wonderful that the insane existing at any given time are few. So also with pauperism. If no poor relief is given there will be no paupers, for some will starve and others will steal. But crime seems to decrease with milder punishment, whether these are the cause of the decrease or only a result of the general civilization of society which is reducing both crime and punishments alike. It is also true that we discover and do something from a large number of cases now who would not be known as defectives under a less perfect administration of government. This is one of the causes of the increase of insanity, as I have already said. Crime is more completely looked after and things are called crime now which would not have been called so a few years ago.

But on the whole I believe that the measures we are taking to treat the defective classes are really reducing the numbers. For one thing, we keep them shut up in institutions, where they are not allowed to propagate their kind, or to practice or teach their vices. A notable exception to this is the county jail system, where prisoners are herded together in idleness to constitute schools of crime and vice. Our methods do also cure many of the defectives. About one-fourth of the insane are permanently cured. From half to two-thirds of the criminals are never convicted a second time. Many paupers and tramps do finally drop back into society again. It is of course a struggle which may be made to appear to be tending one way or the other according as we are optimistic or pessimistic in the best of our own minds. But I take the side of the optimist and believe that we are gradually healing up these ulcers upon society.

The best sign of the future is that public sentiment and legislation is steadily tending in the direction of prevention as well as of cure. Some

measures of prevention like the various phases of child-saving work have been already fruitful of good results. In other cases it is still doubtful what is best to be done in the way of prevention. But I believe the time is coming, when by the combination of public and of private effort we shall greatly reduce, if we do not entirely eradicate the defective classes.

In my dealings with them I am sometimes tempted to despair of humanity. But then I look at our churches and schools, our literature and our industries, and best of all our happy homes, the pledge of the future; and I take heart again, and I remember that after all the total number of prisoners, paupers, insane, deaf and dumb, blind and idiots in the United States is only one per cent. of the population, a less proportion than any other civilized country has.



Map of a portion of Northwestern Montana, slightly modified, and reduced from a map made in September, 1891, by Lieut. Geo. P. Ahern, of the 25th United States Infantry. Scale: One inch equals ten miles.

NOTES ON A LITTLE KNOWN REGION IN NORTHWESTERN MONTANA.

By G. E. CULVER.*

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* The petrographical notes included in this paper were kindly furnished by Dr. William H. Hobbs, of the University of Wisconsin, to whom the writer wishes to make grateful acknowledgment for this and other favors.

INTRODUCTORY.

The party.—In August, 1890, a small party of soldiers under the command of Lieut. George P. Ahern, of the Twenty-fifth infantry, was sent to explore the mountainous region in northwestern Montana. The party as finally made up consisted of two mountaineers, packer and guide respectively, two prospectors eager to take advantage of a new route to possible gold fields, two Indian guides, a squad of soldiers, black as ebony, the commanding officer, and the writer. All were mounted and well armed. Thirty days' rations were carried. It was supposed we would reach an outpost on the west side of the range in a month, to which point another thirty day's supply was sent. Owing to the assistance of various hungry natives and the keenness of mountain appetites our rations lasted but twenty days. Game of all kind was abundant, but the noise made by the passage of such a party prevented very frequent additions to our larder from this source. A few ducks, grouse, and ptarmigan paid our "cook-house" a visit, as did numerous fine trout. Of large game we secured one bighorn, and sixteen mountain goats. The young of the latter are very fine eating; the old bucks taste of musk.

The region covered by the route lies between the 49th parallel on the north and the 47th on the south, and between 112° 30′ and 114° 30′ west. It is divided naturally into the following regions: 1. The western border of the plains, a strip 40 by 130 miles. 2. The narrow belt of foothills, four to twenty miles wide skirting the range. 3. The main range of the Rocky mountains, and 4. The Great Flathead valley with its tributaries. In the eastern portion of this region, well toward the national boundary, the Piegan and Blackfeet Indian reservations are located. In the southwestern portion is the Flathead Indian reservation, extending from Flathead lake down to the Northern Pacific railroad. With the exception of these agencies lying on the outer border of the region it is wholly uninhabited, and, so far as could be learned, almost wholly unexplored.

Object of the journey.—The object of the expedition was to find, if possible, a pass over the main range farther north than any then known, to map the course of the streams and the principal Indian trails. As such a trip might offer some opportunity for geological observation I accepted Lieut. Ahern's invitation to join him.

Region traversed. We left Fort Shaw, Montana, on the morning of August 5th. Our route for the first ninty miles was over a rolling prairie, somwhat west of north, but gradually swinging more to the west, until at the end of the fourth day we went into camp in the foot-hills close up to the base of the main range on the Cut Bank Creek, thirty-five miles from the boundary. A fairly good wagon trail leads to this point, and

our supplies had been so far transported by wagon. They were now transferred to the pack-mules, who entered a vigorous protest against this return to more primitive methods.

Our course from the Cut Bank was nearly north to the national boundary, which we touched first in longitude 113° 30′ west. From this point we moved westerly to the valley of the Belly River, crossing the main range at the head of that stream about fifteen miles south of the boundary, in longitude 113° 40′. From the new pass we descended by the way of Mud Creek into the valley of the North Fork of Flathead river, our course being very crooked, but averaging about southwest by south. Our farthest west, 114° 45′, was reached near the 48th parallel, at which point I left the party, returning home by the way of Flathead lake and south to the Northern Pacific railroad. We were eight days on the plains and twenty-two days in the mountains. Side trips were made as follows: Up the Cut Bank to the summit of the main range, where there is an easy pass at an elevation of 7,800 feet; up the Swift Current from the foot of St. Mary's lakes also to the summit, but a vertical descent on the western side, of many hundred feet barred further progress there. Another trip was made over the divide between MacDonald's Creek and the head waters of the East Kootanie to Glacier Creek. Tho whole distance traveled in saddle or on foot was estimated at 370 miles.

PREVIOUS EXPLORATIONS.

So far as I know, the only explorations in this region previous to our visit were by members of the Boundary Commission along the 49th parallel, and by Dawson, McConnell, and others of the Canadian Survey on the north side of the line. None of these, so far as I can find, traveled far south from the line in the mountains.

GEOGRAPHY AND GENERAL DESCRIPTION.

The plains.—The region lying east of the mountains from Fort Shaw to the boundary is a high prairie, sloping rapidly from west to east and traversed by occasional swift streams from the mountains. The elevations range from 5,000 feet at the base of the mountains to 3,500 at a distance of forty miles east. The Milk River Ridge, where we crossed it, rises several hundred feet above the streams that unite to form the South Fork of Milk River and over a thousand feet above the surface of St. Mary's Lake. This ridge has a nearly north and south trend near the boundary, but bears a little west of south and joins the main range on the upper waters of the Cut Bank. It is the water-shed between the Hudson Bay basin and the Gulf of Mexico. It was followed by Lieut. Ahern and myself to its junction with the main divide of the Rocky Mountains, and the separation was found to be so sharp that from the

summit on the north side of the pass one might without moving from his tracks cast three snow-balls so that one would fall on the Pacific slope, another on the Gulf slope, and a third on that of Hudson's Bay.

The foot-hills.—The high prairie is separated from the mountains by a narrow belt, consisting of a somewhat confused mass of ridges and hills. The ridges constituting the foot hills run in all directions, but the highest are approximately at right angles to the trend of the mountains. The strata are considerably disturbed being usually tilted more, and much more irregularly than the beds in the adjacent mountains. The elevation of these hills is usually under 1,000 feet above the plains, but sometimes runs up to 1,500 feet or more. The line separating the foot-hills from the mountains is quite as sharply drawn in this region as that between the plains and the foot-hills. The latter are usually wooded and somewhat rounded. The mountains, on the other hand, present a frowning battlement of bare and almost vertical walls facing the plain and rising 3,000 to 4,000 above it.

The mountains.—On entering the mountains by way of the valley of the Belly River we found that the range makes makes a sharp bend to the west about twenty miles from the boundary, so that, although we were now traveling nearly south, we were approaching the main divide nearly at right angles to it. The valley is over a mile wide near the boundary, but a short distance up the stream it becomes quite canyon-like. The walls are very steep and rarely less than 2,000 feet high. We went into camp just at the lower end of the canyon, in a dense fog which shut out from view all objects a hundred yards away. In the morning when we looked out of our tents the fog was slowly drifting away and glimpses of the lofty peaks could be had through rifts in the fog. The effect was quite striking. The foot of the mountains was entirely concealed, but at our camp some two miles away the air was clear. Now and then a projecting portion of a mountain side perhaps 2,000 feet above us would be clearly revealed, while above and below the white fleecy veil hid all and seemed to have taken the mountain up bodily and to be about to remove it from our pathway. In other places the upper peaks alone rose clear and distinct above the sea of cloud and seemingly almost over our heads. Altogether it was a picture long to be remembered by those who saw it.

Scenery.—The scenery even along the foot-hills is strikingly beautiful. The lower ridges, rounded and tree-covered, rise abruptly from the plains, while as a background the bare rocky walls of the mountains cut by transverse valleys rise in stately grandeur. A single glance takes in a view of level plain, tumbled foot-hills, and lofty mountains, the latter softened somewhat in their outline by distance. As the summit of the main range is neared plains and foot-hills disappear and the landscape is made up only of rocky mountains lifting their jagged summits above

deep narrow valleys down which swift torrents, from the snow-fields and small glaciers above, roar and tumble over their rocky beds, or plunge from ledge to ledge in beautiful cataracts. At intervals in these valleys the falling debris from the canyon walls has dammed the stream and beautiful lakes are formed. The river we ascended takes its rise in one of these lakes, lying in a beautiful amphitheatre at the very foot of the continental divide. The lake is about two miles long and a mile wide. It is supplied wholly by three small glaciers which cling to the side of the mountain 2,000 feet above it. The amphitheatre contains about eight square miles. It is the result of a loop-like bend in the dividing ridge. Its walls are almost vertical, save one portion on the southeast side, and are from 2,000 to 3,500 feet high. The new pass is at the head of this amphitheatre, 7,250 feet above sea.* The dividing ridge itself, the backbone of the continent, is surprisingly narrow and quite sinuous. It is terminated at the summit by a thin wall varying from 50 to 300 feet in thickness and surmounted by pinnacles and chimneys which emphasize its wall-like appearance. It is in many places so narrow and rugged that it would be impossible to travel along it without the use of ropes and ladders. It preserves this peculiar mural character for at least 50 miles.

Ahern Pass.— Ahern Pass is 2,000 feet above the lake at its foot, and the summit wall on either side of the pass was estimated to be at least 1,500 feet more. The entire force had worked two days in making a trail from the foot of the talus slope to the summit of the pass. The assent is very steep and was made with difficulty.†

The Western Slope.— The western slope is in strong contrast with the eastern. A gentle grassy declivity, down which we could indulge in the rare luxury of riding, stretched away for a couple of miles, after which it rapidly became steeper, following the changing dip of the strata, until we were obliged to dismount and lead our horses through the thick tangle of brush with which the steeper slopes were covered. We passed the summit in a biting wind accompanied by rain and sleet, with a temperature of 39°. As we descended the rain increased. We marched in single file through the dripping beech brush, halting every few yards for the

* It was here that the services of our Indian guide came in play. One of the prospectors with us had three years before camped at this very spot with three other men and had tried for a week to find some means of scaling the rocky wall which barred their way. They were used to the mountains, but were obliged to give up and retrace their steps.

† "Aug. 22. As I led the pack-train out this morning I felt extremely anxious as there were several places on the trail where a misstep meant certain death. At the north end of the lake the trail zig-zags up a very steep grassy slope for 800 feet and then over loose slide-rock — talus — for 1,100 feet higher to the cut-walls, which loom up 2,000 feet above the slide-rock. The trail now follows narrow ledges straight for the gap, which is on the same level and 500 yards west. At one place we climbed a narrow and very steep rock fifteen feet high, in which we had to cut steps. We led our most troublesome animals over this. My feelings were indescribable when I started up this rock, not knowing what the horse would do. The ledge was about eighteen inches wide, the upside wall sloping back. On the lower side was a fall of 1,900 feet." — From Lieut. Ahern's official report.

axemen to cut a trail. Sometimes we could travel for a few rods in the bed of the stream. Then obstructions in the form of cascades or huge rocks would compel us to cut a path up the steep banks and pursue our course along the sloping sides of the valley. The descent grew constantly steeper and our progress correspondingly difficult and slow. For four hours we toiled along in this fashion, every hundred yards in advance bringing us to greater difficulties. At last, wet to the skin, our teeth chattering with cold, and thoroughly worn out, we cleared a place large enough to put up our tents and went into camp. What a luxury a fire is under such circumstances! We had eaten an early breakfast at the foot of the lake on the other side. Since that time we had been working incessantly, most of the time in a pouring rain, until five o'clock in the afternoon found us in the condition described, two and a half miles down the Pacific slope in a dense tangle of fallen logs, thickly overgrown with brush. We had our supper, warmed ourselves, and were fairly comfortable in a couple of hours, but there was nothing for the horses to eat and we were obliged to tie them to the trees for the night. The next morning they were taken back a mile on the trail to the last grass we passed, where they were pastured for a couple of days while the men cut a trail two miles to the more open country in the valley below.

A side trip.— Leaving the main party here to rest for a few days, Lieut. Ahern and myself with the prospector, Lewis Meyer, made a four days' trip up MacDonald's Creek and over the divide to the headwaters of a branch of the East Kootanie. Our purpose was to examine the large glacier described in another portion of this paper. The route lay across a succession of ridges, ranging in elevation from 500 to 2,700 feet above their respective valleys. The lower slopes are densley wooded and fallen timber added to the work of climbing. The summits of all except the highest ridges were quite level grassy parks, with borders and patches of pines. From any of these summits a magnificent view was to be had of the great backbone over which we had climbed. Fifty miles of it could be seen at once owing to the great bend it makes to the westward.

On our return trip we endeavored to shorten our route by taking a short cut over the summit of a spur of the main range. This took us up 8,000 feet. A rapid descent of 2,000 feet was then made, and the first part of the cut off had been successfuly accomplished. After a couple of miles of easy going we started on another descent of 2,000 feet into the valley of MacDonald's Creek. We found the descent extremely difficult. It was so steep that we kept our feet with difficulty. Impassible ledges were frequently in our way and multitudes of fallen trees encumbered the less precipitous slopes. We were three hours making the first half mile. Darkness came on while we were still three miles from camp and we spread our blankets on the stony banks of the stream and lay down to wait for daylight. We had eaten the last of our rations at noon,

expecting to reach camp that evening. We started on at 6 A. M., and at 10:30 rode into camp and ordered dinner.

We were now not more than eight miles from the large glacier elsewhere mentioned, and I was eager to visit it. But travel in this region is indescribably difficult; we had spent four days in the side trip I have just described, our rations were nearly gone, and we had yet nearly a hundred miles to go before we could reach our base of supplies. It was therefore plainly evident that we must move on and leave this most attractive region, in the hope that at some future time fortune may be more kind.

Mud Creek.—Our route now was down the valley of Mud Creek to the north fork of the Flathead. This stream, Mud Creek, flows between steep rocky walls from 1,500 to 2,000 feet high. They gradually grow less precipitous and the valley widens as we descend. The lower portion of the valley has been covered with a thick growth of pines. In the winter avalanches sweep down the steep slopes on either side and towards the bottom carry everything before them; not a stick or a stone is left. The debris thus accumulated is hurled into the bed of the stream and in some cases permanent dams have been thus made and lakes formed. Some of these have in the lapse of time become marshes stretching clear across the valley. These marshes are soft and miry for pack animals, hence the name Mud Creek. The existing lakes are half full of the slowly decaying trunks of the pines swept into them. A great mass of trees, earth, stones and snow, the remains of an avalanche of the previous winter still lay at the foot of one of the many wide swaths cut through the pines, a silent but eloquent witness of the destroying work of the snow.

Flathead Valley.—The great Flathead valley, although deeply eroded, is not a valley of erosion, but is a good example of a synclinal valley. It is a deep trough between the Rocky Mountain range on the east and the high ranges to the west. Its character will be seen when it is stated that if a line be measured from the summit of the Rockies to the Flathead valley, and another an equal distance out to the plains eastward, the elevation of the point on the plains will be found to be from 1,000 to 2,500 feet higher than the corresponding point in the Flathead valley. The same is true of the great Columbia-Kootanie valley of British Columbia. Dense forests of pine, spruce, hemlock, etc., crowd the valley of the Flathead and those of its tributaries on the east down nearly to Flathead lake. Here on the prairie-like openings a few ranches have been established.

GEOLOGICAL NOTES.

The plains formation.—A large portion of the beds forming the surface of this portion of the plains I judged to be Laramie. This conclusion is based only on the lithological character of the beds, as no fossils

were found at any point.* Beds which I refer to the Laramie were first seen on Dry Fork, a branch of the Marias River, and they were traced from there all the way to the 49th parallel. On the Two Medicine, near the Mission, the supposed Laramie has been cut through by the stream and black shales of presumably Cretaceous age are exposed. The Laramie has a thickness here of about 500 feet. In most of the exposures seen it has a greenish color and the beds consist of an intimate admixture of sand and clay without the usual seams of lignite and with fewer concretions than are commonly observed in these beds in North Dakota. On a branch of Swift Current, near St. Mary's Lakes, the Laramie was again seen close up to the base of the mountains, underlain by soft black shale, which appears to be Benton. No tertiary beds were seen although they may exist here. The beds later than Laramie were small local fluviatile deposits still in process of formation.

The foot-hills.— The rocks exposed in the foot-hills seem to be largely of Cretaceous age, though there are some beds of limestone that can hardly be so young as Cretaceous.

Structure of the mountains.— I have already referred to the precipitous character of the east base of the mountains.† This appearance is due to the structure of this portion of the mountains. A fairly correct idea of this structure may be obtained by imagining a long fold to be fractured along the anticlinal axis, and the eastern half to fall back to nearly its original position, leaving the western half of the fold to stand at its elevated position. The plane of fracture thus becomes the eastern escarpment of the mountains and the foot-hills are the disturbed edges of the upper strata of the down-sinking eastern half of the original fold. I suppose it is altogether more probable that the eastern half never rose at all, but that the faulting was accomplished by the simple elevation of the western half. The effect is the same in either case. It will be understood I presume that the uplifted western portion does not present an unbroken wall for hundreds of miles as might perhaps be inferred from what I have said. I have spoken of a single fault; in reality there are several, roughly parallel to each other and less so with the general trend of the range. There have also been transverse fractures, or else the streams have done valiant work in cutting through the rocky walls in which their beds are made. The total result of all the forces at work

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* At Fort Shaw the Sun River runs over shales containing fossil Inocerami, beautifully preserved.

† Captain Twining, of the Boundary Commission, speaking of this region, says: "I had been led to suppose that the ascent to the summit was a gradual slope, and was greatly surprised to find that the rolling prairie abutted abruptly against an impassable escarpment of rocky precipices It was found to be impossible to carry a continuous line even so far as the crossing of the Belly River, and the three stations at this point are connected by traverses; the connections between the two final stations are made by a traverse of thirty-five miles through the South Kootanie Pass." Report of Chief Astronomer, p. 65.

here, whatever they were, is this: The strata once continuous and level have been slightly flexed and broken into huge blocks from one to two miles in thickness, and five, ten or fifteen miles in each of the other dimensions. These blocks have been heaved up to their present position. The mountains thus formed have two features in common. The side facing the plains has been most elevated. They thus present steep walls to the east, with long gentle slopes to the west. In other respects they differ. Some of them, for example, have not only steep walls on the east, but also on the south, with a gentle slope on the other two directions. Others reverse this, having north and east facing walls, and slopes on the west and south. The structure here outlined is marked in the vicinity of the 51st parallel by an additional feature. The vertical displacement is reported by McConnell * as being over 15,000 feet, and accompanying this is a horizontal displacement or overthrust of from two to seven miles. This latter feature may occur south of the 49th parallel, but I saw no evidence of it.

Strata exposed.--The rocks exposed in the walls of the valley of the Belly River give a practically continuous section of 5,000 or 6,000 feet of strata. They are all rather thin bedded and the whole series seem to be perfectly conformable. The beds consist, from below up, of yellowish gritty limestones, red sandy shales and sandstones, and green and black shales with more limestones at the top. The colors are quite distinct and give a broadly banded appearance to the high walls which form the sides of this valley, making it easy to trace the stratigraphic relations as we ascended. The dip was slight but towards the south or away from the plains, as it is along the range farther south. As we were climbing somewhat rapidly in the direction of the dip we were steadily getting higher in the series. No fossils were seen during the trip. The sandstones often showed wind-drift structure and ripple-marks and the red shales were full of mud cracks. The black shales and limestones indicated deeper water. From base to summit there is an entire absence of crystalline rocks.

The rock exposures on the Pacific side were not so numerous, but showed the same order of the same beds, the only difference being the addition of several intercalated beds of diorite, and the fact that the strata in the mountains west of the main range have been more strongly folded. The disturbance producing this folding occurred after the intrusion of the diorite. This is shown by the fact that the latter has shared in the folding and has been much fractured in the process.

Igneous rocks.--1. Location and character of outcrops. The outcrops of igneous rocks are on the headwaters of MacDonald's Creek. The first one observed is about two miles from the summit of Ahern Pass (see 1 on map). The bed is about fifty feet thick, is smoothly interbedded with the stratified rocks of the region, and is exposed for about

* Annual Report Canadian Geological Survey, 1886, vol. 2, p. 33D.

four miles along the side of the valley. Five miles down the valley on the other side another outcrop about an eighth of a mile long occurs. (See 2 on map.) It has the same thickness and general character as the first mentioned.

These two exposures are on the east fork of MacDonald's Creek. On the west fork of this stream, at its source, a very extensive exposure is found. This valley is continuous with that of a stream flowing in the opposite direction, a branch of the East Kootanie.

The western wall of this common valley is lined with a sheet of diorite (see 3) from the bed of the stream up to a height of a thousand feet. The slope is about 20° from the horizontal. For at least a half a mile this sloping wall of rock has been smoothed and planed by the ice, and so enduring is the rock that the glacial polish still shows plainly. This bed has about the same thickness as the others.

A fourth exposure occurs a mile down the valley on the Kootanie side (see 4).

Other exposures seen at a distance occur north of Mt. Ruger (see 5).

The uniformity in the character of this rock, macroscopically at least, over such a large area is noteworthy. The same may be said of the manner of occurrence. The sheets have been intruded between the stratified beds so neatly as to present the appearance of being original members of the series. The thickness too is remarkably uniform, averaging about fifty feet. The shales near the contact, above and below, have been abaked and

On the head waters of McDonald's Creek: S. shale; R. S. red shale; G. S. green shale; A. beds of diorite.

hardened by the heat and pressure. The diorite sheet, although in some exposures the surface formation and in others hundreds of feet below the surface, is nevertheless found at very nearly the same geological level in each of the exposures.

2. *Petrographical notes.*—The petrographical study of this mass of rock has been made on four specimens, three of which are from the locality marked 1, where a cliff almost forty feet high is capped by a green sandy shale. Specimen 1 is from near the bottom of the cliff, perhaps thirty feet from the contact. Specimen 2 was taken from a point about twenty feet, and specimen 3 about ten feet below the contact, so that the specimens show in inverse order the gradations in characters of the rock in passing from the contact toward the center of the mass. The sedimentary rock of the cap is well baked. The other specimen of the eruptive rock which has been sectioned is from the contact with shale at locality 3, and shows portions of both rocks in the section.

The rock is all cases much decomposed. Specimens 1, 2 and 3 show a steady decrease in the coarseness of texture, the crystals in No. 1 having average dimensions of from one to two millimeters, with occasional hornblende crystals sometimes attaining to a half centimeter in diameter. The crystals in No. 2 will average about one-half, and those of No. 3 about one-fourth these dimensions.

All the specimens from locality 1 have a more or less apparent granitic structure with a tendency to porphyritic development of the hornblende. A dull greenish lustre so characteristic of rocks of this type is apparent in all, but somewhat irregularly distributed. The lens reveals in the coarser specimens feldspar, augite, hornblende, black ore material and pyrite. When the rock was powdered a considerable portion of the ore material was strongly attracted to the magnet, indicating magnetite. In addition to the minerals above mentioned the microscope reveals in all sections ilmenite, leucoxene, quartz, chlorite, zoisite, and apatite. Section 2 contains well crystallized sphene and section 3 epidote as well as sphene.

The more coarsely crystalline of the three shows in section a plagioclase which is very much decomposed and is associated with more or less micro-pegmatite. The nature of the alteration seems to be saussuritization, zoisite being identified as one of the pro lucts by its moderately high index of refraction, its parallel extinction and low interference colors. Augite and hornblende are present in about equal proportions, but the crystals of the former are much larger than those of the latter. The hornblende is the brown variety with deep colors. The absorption is $c > b > > a$. It is always well outlined and shows perfect prismatic cleavage. It is very unstable, the initial stages in the alteration consisting apparently in a change of color to green, followed by a decomposition to chlorite. This decomposition has in some cases proceeded so far

as wholly to replace the crystal, in other cases the chlorite occupies but one half of the crystal or appears in inclosed areas within the crystal. The chlorite is strongly pleochroic (yellow to green), and is often radial (delessite.) Both hornblende and augite are frequently twinned. The small amount of quartz not in the form of micro-pegmatite may be either original or secondary. The black ore material shows in some cases in square sections and is strongly attracted to the magnet in the rock powder. Yet many grains are almost entirely changed to leucoxene, indicating the presence of titanium, probably as ilmenite. Apatite is present though not in great abundance.

Section 2, from a specimen taken at a point about ten feet nearer the contact, shows besides a more finely crystalline texture than section 1, certain differences in mineralogical composition. It contains more quartz than micro-pegmatite. The feldspar is more altered. The magnetite shows a greater tendency to appear in skeleton growths, and well crystallized sphene, as well as considerable leucoxene is present. As in specimen 1 the augite is but little altered, while the hornblende is in many cases much decomposed to chlorite.

Section 3 shows very beautiful skeleton forms of magnetite, long and slender growths running entirely across the field with a magnification of thirty. Imperfect parallel growths of brown hornblende about augite are seen much as they have been described in the augite diorite from Somerville, Mass.,* with which this rock presents many analogies. Like section 2, this section contains sphene, and epidote was made out, probably a product of the combined alteration of feldspar and hornblende. The characters of this rock as made out in the three sections agree well with those of the camptonites of Rosenbusch.

In section 4, from the contact of the igneous intrusion with metamorphosed green shale (locality 3 on map), the decomposition is too great for the section to be of great interest. It can be seen, however, that the feldspar was in lathshaped crystals with perfect outlines, oriented without reference to one another. The structure is that of a typical diabase. Between the altered feldspar laths is a mass of decomposition products of a greenish or dirty brown color in which chlorite is made out, and the mass is crossed by serrated magnetite skeletons. No distinct crystals of either hornblende or augite can be made out, and it seems probable that both hornblende and augite are entirely altered.

In order to form reliable conclusions as to the dependence of the rock characters on the distance from the contact, observations should be made on a larger number of sections at several localities somewhat widely separated. The evidence obtained so far as it goes, seems to be, (1) that there is a gradation in texture, the finest grained rock being nearest the

* Wm. H. Hobbs, on the Petrographical characters of a Dike of Diabase in the Boston Basin: Bull. Mus. Comp. Zoöl., Harv. Coll. xvii. Plate 1. fig. 2. March, 1888.

contact; (2) that the diabase structure is restricted to portions of the mass which consolidated quite near the the contact; (3) that nearness to the contact measures the tendency of the magnetite to appear in skeleton forms; (4) that the hornblende and augite show more tendency to crystallize in parallel growths nearer the contact.

In his study of the diabase dykes of the Rainy Lake region,* Dr. Lawson has shown that in some cases a porphyritic structure, a diabase structure, and an allotriomorphic-granular or granitic structure in turn characterize the rock of a single dyke in passing from the contact toward the center of the dyke. The conditions of consolidation of the rocks here studied have not been such as to give rise to the formation of a porphyrite, but with that exception the observations are quite similar.

EXISTING GLACIERS.

At the close of his interesting paper on this subject, Mr. I. C. Russell† writes as follows: "Existing glaciers were discovered by Prof. Pumpelly during the progress of the Transcontinental Survey, at the head of the Flathead River in northern Montana. No scientific account of these observations has yet been published; but I am informed by Prof. Pumpelly that two glaciers were seen in the mountains in which the East Fork of the Flathead rises at an elevation of about 7,000 feet. It was observed that the glaciers broke off suddenly at the summit of precipices 2,000 feet high and that the waters flowing from beneath the ice had the milky color characteristic of glacial streams. The mountains in which these glaciers were discovered extended northward into British America, and are supposed to reach their greatest elevation north of the boundary. It seems safe to predict that when this little known region is more fully explored additional glaciers will be found about the peaks known as the Crows and Mountain Head." I am unable to determine from this account just where the glaciers seen by Prof. Pumpelly are. Two glaciers answering almost perfectly to the description here given are plainly visible from the crest of the Milk River ridge, and from very many points on and near the International Boundary. These glaciers, however, are on the head waters of the Belly River, a fact which could not escape Prof. Pumpelly's notice had he come near enough to see the milky color of the water. He would also have seen that there were four instead of two glaciers; hence I conclude that these are not the ones referred to by him.‡ Small glaciers are numerous in all the higher mountains within twenty or thirty

* Petrographical Differentiation of certain Dykes of the Rainy Lake region: Am. Geol., March, 1891.

† Existing Glaciers of the United States: 5th Ann. Report U. S. Geological Survey, p. 347.

‡ Since the above was written I have seen Prof. Pompelly and find that the region referred to is northwest of the Cut Bank Pass, between MacDonald's Creek and the main divide of the Rocky Mountains. It seems entirely probable that this glacier is in the same mountain mass as those described in the present paper.

miles of the boundary, but are more numerous and larger on the north slope of the portion of the range which bends to the west, and especially on a spur or branch of the main range nearly parallel with this same portion of it and some miles farther south. Judging from what I saw I presume there are twenty or thirty glaciers in this region. Several terminated at the crest of high precipices with falls varying from 500 to 2,500 feet. The thunderous roar produced by these ice falls is unlike any other sound I have ever heard. The nearest approach to it is that of distant thunder. In each of the cases of this kind observed save one the ice did not again accumulate at the foot of the fall, but melted as soon as it reached the lower level. In the single exception noted the fall was probably not over 500 feet and the direct rays of the sun did not fall upon the ice, which accumulated and moved on down the lower slope pushing its moraine ahead of it. One fair sized glacier on Quartz Creek extends down into the bed of a little lake which it supplies. Most of the glaciers were wider than long, their length being apparently determined by the shadow of the parent mountain.

The Mt. Dana glacier, described and illustrated by Mr. Russell* is a good type of the average glacier in this region. 'One somewhat larger than that glacier was made the object of our only side trip for any such purpose. It lies in a small amphitheatre at the head waters of the East Kootanie near the 114th meridian, about fifteen miles from the boundary. Its width is about two miles and its length one and a half. Although it is on the northeast side of the mountains a large part of its surface is exposed to the sun's rays fully two-thirds of the day. Its surface is remarkably smooth and free from crevasses. Its front is oval, like an inverted wash-bowl, and it is so steep that it can be ascended at only one or two points. The thickness of the ice a few hundred feet from the edge was estimated at from 250 to 500 feet. On gaining the summit of the glacier it was found to stretch away smooth and nearly level to the adjoining mountain. Patches of morainic supplies and scattered bowlders were seen here and there on the front half. There was no dust upon the surface, nor were there any dirt bands in the ice. The terminal moraine of this glacier is quite imposing. Approaching its highest part from without, one must climb 100 feet to reach the summit; from there down to the edge of the ice, forty feet at the time of my visit. This was not, however, the bottom of the moraine. It varies at other points down to perhaps fifteen feet in height. Its length is fully two and one-half miles, and it varies in width from 150 to 400 feet. It is composed wholly of somewhat subangular stones, varying in size from tiny bits up to huge blocks weighing forty or fifty tons. Six parallel ridges of rock-fragments on the inner slope of the central portion of the moraine indicated as many successive advances and retreats of the ice.

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*5th Annual Report U. S. Geol. Survey.

Whether these advances and retreats were annual I could not tell. We camped for the night near the banks of one of the milky streams flowing from the ice, and found in the morning that the volume of the stream had fallen off about one-third, and the water was much clearer. I concluded therefore that not only the melting, but the motion also of this glacier depends largely on the heat of the sun. The slope on which it lies is quite gentle. A few miles down the valley an older moraine, some four miles in length but much lower than the present moraine, indicates a stage in the recession of the large glacier of which the present is the shrunken remnant only. The glacier just described was the largest seen close at hand. Indeed only one was seen in the whole region that was larger. This, if it be a true glacier, is much the largest in the United States, exclusive of Alaska.* We saw it from many points, at distances varying from eight to twenty miles. It lies in a horse shoe shaped basin or valley at an elevation of about 7,000 feet and covers, as near as I could estimate, an area about four by six miles in extent. We passed half way around it but did not find the stream that must flow away from it, unless a somewhat remarkable branch of the Belly River has its source there. This stream flows out from the foot of a precipitous wall, fully 2,000 feet high, forming the northeast face of the continental divide. The rocky wall has not a fissure in its face from top to bottom. The ice field lies on the opposite side of the ridge fully ten miles away and 2,000 feet above the point where the stream comes forth. The latter has the milky character common to glacial streams and flows from the direction of the large ice field. The strata dip from the ice field in the direction of the stream. Further evidence of its relationship must await future investigation.

FORMER GLACIERS.

Western border of drift.—So far as my observations extended the portion of the plains traversed by us is entirely devoid of drift material, with exceptions hereafter noted. Dr. G. M. Dawson,† in a journey from Fort Benton on the Missouri, to Fort McLeod, British Columbia, found bowlders all the way. As his route was some sixty or more miles east of mine, it would seem that the western limit of drift material lies between these two routes, and as Dr. Dawson found undoubted Laurentian erratics at or near the 113th meridian on the international boundary, it is likely that the western limit of drift for 100 miles south of the boundary is somewhere from forty to fifty miles east of the base of the mountains.

Ice tongues of the eastern slope of Rocky Mountains.—Several ice tongues have at some time descended from the range on the west and

* The location of the large glacier was in some way left out from the original map. Its location on the present map is only a guess at the correct place.

† Report of Progress of Geol. Survey of Canada, 1882-84, p. 147C.

have plowed their way nearly at right angles to the range, and consequently directly in the face of the great Laurentian ice sheet for many miles out on to the plains. The trough-shaped depressions made by these alpine glaciers are now sometimes occupied by small lakes walled in on all sides except towards the mountains by the old moraine. Sometimes the water has cut through the morainic walls and completely drained the lake. In such cases it usually happens that the swaying of the stream from side to side has cut away the whole front portion of the moraine, leaving two long parallel ridges on either side extending back along the course of the stream to the mountains. In still other cases the troughs once occupied by the ice are dry and empty. Measured on the plains these ice tongues varied from five to forty miles in length and from half a mile to five miles or more in width. Of their mountain extensions I shall speak later. Their thickness can in some cases be inferred from the appearance of the moraines. These are much higher on the ice side than on the outer or plains side, as would be expected, since the ice came down upon the soft Laramie beds at a steep angle. The glacier which plowed out the beds of St. Mary's Lakes was the largest of all in this region and must have been of no mean proportions. These lakes, two in number, lie at nearly the same level, the one just outside the narrow belt of foot-hills, the other extending through the foot-hills reaches the very base of the mountains. The lower lake is about five miles long and two wide; the upper is seven or eight miles long, but not more than two miles wide. The stream discharging them is 150 feet wide, three feet deep, and very swift. From our camp at the foot of the lower lake the stream seemed to have cut through a moranic wall about 300 feet high a few hundred yards below the foot of the lake. I found, however, on climbing up this slope that the ice had ridden over the seeming wall, which was not a moraine at all, but a terrace marking the depth of post-glacial erosion of the stream. The topography of this upper level was unmistakably that of a ground moraine, yet there was something unfamiliar about it which I was at first unable to interpret. There are three glacial lakes on this terrace, one a mile in diameter, and the whole region showed unmistakable evidence of having been covered with water since the retreat of the ice. On the sides of the Milk River ridge, which forms the eastern walls of St. Mary's valley, terraces, a dozen or more, extend up to a height of at least 800 feet above the present level of the lakes. These, with the peculiar outline given to the knobs and hills, constitute the unfamiliar features spoken of. I followed down the valley five miles or more, but saw no signs of a terminal moraine or barrier ridge of any sort that could have held the waters at such a level as is indicated by the terraces. I concluded, therefore, to adopt tentatively the hypothesis that the Laurentian ice sheet was the barrier; that it had sent a tongue up the St. Mary's valley far

enough to pond back the waters and form the lake whose terraces I had seen. The southern extension of this lake was the steep-walled flord-like valley of the upper St. Mary's Lake. On the east the water was held in by the Milk River ridge; on the west by the mountains. How far north it extended would depend on the position of the hypothetical ice barrier. Lack of time prevented further investigation of this region.

Ice records west of main range.— After crossing the continental divide the valleys on the western slope were found to give evidence of heavy glaciation. Planed surfaces and trains of bowlders were common but were confined to the valleys. Bowlders of undoubted glacial origin were found at an altitude of 7,250 feet.

ORIGIN OF THE ICE-TONGUES OF THE EASTERN SLOPE OF THE ROCKY MOUNTAINS.

In passing up along the eastern flank of the Rockies, as we came near enough to them to begin to encounter the moraines of the ice-streams spoken of in a previous paragraph, certain crystalline bowlders were occasionally observed. On examination they proved to be a rather fine-grained diorite.

As we moved up the valley of the Cut-Bank these bowlders grew quite numerous.

In the trip to the summit of Cut-Bank Pass it was confidently expected that the outcrop of this diorite would be found. However, although the bowlders were to be seen all the way, the rocks in place seemed to be wholly of sedimentary origin and were very little if at all metamorphosed.* The failure to find the igneous rock was accounted for by supposing that it might now be hidden by debris from the cliffs above it. A second ascent was made up the Swift Current with no better results so far as finding the diorite was concerned. This valley is twenty miles from that of the Cut-Bank and there is no communication between them; but diorite bowlders occur in this valley also.

The third ascent was by way of Belly River. As before stated, the bare walls of this valley afford no hiding place for beds of any prominence whatever. The exposure is peactically continuous for fifteen miles from the summit. No diorite or other eruptive or crystalline rock occurs in place in this valley. At the head of this river on the summit of Ahern Pass, at an altitude of 7,250 feet, bowlders of the diorite, some of them glaciated, were quite abundant.

Some ten or twelve hundred feet below the summit, on the Pacific slope, a mile and a half from the pass, the diorite was found in place. The exposure is four miles in length. It occurs on both sides of the valley, which is fully a mile wide.

* Diorite bowlders were seen however within 800 feet of the summit, at 7,000 feet elevation.

There are many other exposures on the upper waters of McDonald's Creek, where the diorite is the surface formation and is strongly glaciated. On the divide between the East Kootanie and McDonald's Creek, the sloping west wall of the common valley is a bed of this diorite. It has been planed and smoothed for a thousand feet from the bottom of the valley by the ice stream that once flowed through this gap.

In brief, then, the evidence is this:

1. Trains of diorite bowlders were traced from the plains east of the mountains up to the axis of the range, along three lines widely separated from each other.

2. No outcrops of diorite could be found on the eastern slope on any of these lines.

3. Extensive, heavily glaciated outcrops occur on the western slope 1,000 feet below the summit of Ahern Pass.

4. On the Belly River line, the bowlder train was followed over the summit of Ahern Pass, down the western slope to the parent ledge.

From these facts, then, it seems clear that the ice-tongues which crept down the valleys on the east slope of the Rockies, and plowed their way out some miles beyond the foot-hills, did not originate on the east side of the range; but were pushed up over the continental divide through the gaps and passes mentioned, and probably through others not yet examined, by some force from the west. What that force was, admits of but little question. That it was an ice sheet of some vigor is obvious. That it was separate and distinct from the Laurentian ice sheet, at least to high latitudes, is equally clear. Dr. Dawson has brought forward evidence * to show that a great ice sheet which he has called the Cordilleran Glacier once occupied the region between the Coast Range and the Rocky Mountains in British Columbia, and later he has found evidence † that the ice ran through the gaps in the Coast Range and down to the sea.

President Chamberlin ‡ has shown that the ice extended southwest to the vicinity of Lake Pend d' Oreille, Idaho. Mr. Bailey § Willis has found similar evidences in Washington. Neither of these observers, however, connect the ice records seen by them with the Cordilleran Glacier.

From such observations as I was able to make, it is my impression that the ice ran in the valleys, in streams whose courses were determined partly by the source but mainly by the mountain topography. The region lying between the main range on the east, the Rocky Mountains

* Quart. Jour. Geol. Soc., vol. 31, p. 89, and Quart. Jour. Geol. Soc., vol. 34, p. 72

† Geol. Mag. Decade III, vol. 5, 1888, p. 347

‡ Bulletin No. 40, U. S. G. S.

§ Ibid.

proper, and the Cascade range is very mountainous. The ranges are broken and irregular. Short spurs and ridges trending in various directions give rise to a net-work of valleys. Through this labyrinth the ice-streams made their way. Some of them found more or less direct passage into the great Flathead valley and there died a natural death. Others were caught by the transverse spurs and carried up over the main range from whence they descended to the plains on the east.

The tendency toward a southerly movement may indicate a northern origin for the ice. It is evident, however, that local supply would be abundant, if, indeed, it might not be sufficient to account for all the glaciation observed.

MADISON, Wisconsin, December 29, 1891.

ON A NEW OCCURRENCE OF OLIVINE DIABASE IN MINNEHAHA COUNTY, SOUTH DAKOTA.

By G. E. CULVER and Wm. H. HOBBS.*

Field Notes.—The rock considered in this paper occurs in the southeastern part of South Dakota, in Minnehaha county. The country rock is the Sioux Quartzite, large outcrops of which occur throughout this and adjoining counties.

The quartzite lies in gentle folds with axes approximately east and west. In the vicinity of the diabase the dip is to the south at an angle of 8° the outcrop being on the north of the diabase.

The surface of the latter lies somewhat below the general level of the district, in the valley of one of the small tributaries of the Big Sioux.

The stream has cut a trench twenty-five or thirty feet deep and a mile in length directly through the diabase. Whether this represents the width or the length of the mass it is impossible to say, there being no other exposures.

No actual contact with the quartzite could be found, but from the fact that undisturbed beds of the latter occur very near the diabase, it may be inferred that the latter is older than the quartzite, and may have been an island in the sea in which the quartzite was deposited.

On the other hand the diabase gives no indication of having been poured out upon the surface. Not only is it completely crystalline but the size of the crystals indicates slow cooling. The only way in which it seems possible to harmonize these facts is to suppose that the ancient rock with which the diabase was once covered had been entirely removed before the deposition of the quartzite. Such a supposition must rest on very insufficient data at present however.

No other eruptive rock occurs in either Dakota outside of the Black Hills, 300 miles away, but some seventy or eighty miles northeast of this locality, in the Minnesota valley, there are many outcrops of eruptives in the gneisses and other ancient rocks of that region. In order to compare the South Dakota diabase with these rocks, the best exposures in the neighborhood of Granite Falls, Minnesota, were visited and specimens collected representing a dozen or more varieties. Macroscopically, none of these bore very close resemblance to the South Dakota diabase.

* Field notes by G. E. Culver and petrographical notes by Wm. H. Hobbs.

Unfortunately the specimens were lost before sections had been made from them so that the comparison was not carried to completion.

Perhaps the most prominent field characteristic of this rock is the profound decomposition it has suffered. How much of it has been removed by erosion it is impossible to say, but the whole exposure from its upper surface down to the bed of the stream, a distance of twenty to twenty-five feet, seems to be thoroughly disintegrated. It apparently maintains its vertical position only by the support of a net-work of thin quartz veins which ramify through it in all directions.

The decomposition has brought out a set of lines indicating a horizontal movement in the fluid mass. Parallel with these apparent flowage lines, a layer of bowlders of decomposition, well rounded, but still *in situ*, extends for some distance along the bank of the stream. The rock below this layer of bowlders is as much decomposed as the upper portion. The limit of decomposition seems to be marked by the position of the stream. The rock in its bed is firm and apparently unaltered.

Just below the lower end of the diabase exposure, an excavation was made to determine if possible the relations of the diabase to a bed of siliceous flour which occurs there. (Another bed of this material occurs about a mile farther down the creek resting on the quartzite.)

About two feet below the surface a layer -- not continuous -- of steatite about two inches thick was encountered. Immediately below this steatitic layer was a stratum of the same material containing hard fragments up to a quarter of an inch in diameter. Whether these were fragments of sound diabase, or pieces of the quartz veins was not determined. Below this the rock became gradually more firm so that at a depth of six inches a pick could be driven into it with difficulty.

It does not appear that the extensive decomposition of this rock is due to any inherent tendency in that direction, but rather to the peculiar circumstances of its history.

In the warmer and moister portion of our country south of the glaciated area -- in fact, in any unglaciated region where ancient crystalline rocks occur, extensive and profound decomposition very commonly occurs.

This rock, however, is in the more arid portion of the glaciated area. The surface of the adjacent quartzite is planed and scratched after the orthodox glacial fashion.

Within half a mile of the diabase outcrop, on a tabular surface of quartzite, two distinct sets of striæ occur. One set runs S. 20° E. and the other S. 50° E., indicating at least two ice movements.

These visitations of the ice must have swept off all previously decomposed material from the diabase, so that the present accumulation is in some degree a measure of the work of the destructive agencies since the second of the two ice invasions to which reference has been made.

Further light is thrown on this question by the fact that in its final advance the ice did not overrun this particular region. Hence whatever accumulation there was as a result of inter-glacial decomposition was preserved to be added to by the same disintegrating forces in post-glacial time.

If one were inclined to jump at conclusions, the inference would be easy, that since rocks very similar to this, both in character and age, within the region covered by the ice in its last advance show almost no accumulation of decomposed material, while this rock, perhaps equally enduring, but lying just without the area of the last advance, is so deeply decomposed, therefore the time between the second and the last advance of the ice is much greater than that which has elapsed since its final retreat.

This evidence would have more value as a time measure if there were other exposures of the same rock within the adjacent latest glaciated area. Unfortunately none occur. Of those that do occur from the granites near Big Stone Lake to the basic eruptives at Granite Falls no one of them, so far as can be learned, exhibits any appreciable accumulation of decomposed material. The same is true of this class of rocks in Wisconsin and northern Michigan and generally throughout the northern United States and Canada.

So far as it goes, then, the testimony of this rock falls in with that which has been derived from comparisons of the till of the earlier and the later glacial epochs. These comparisons all go to show that inter-glacial time was vastly longer than post-glacial time.

Petrographical Notes.—The fresher rock is a very coarse-grained olivine diabase. The hand specimen shows lath-shaped twinned feldspars over a quarter of an inch in length, sometimes with a dull greenish hue as though partly changed to saussurite. Large columnar augite crystals, penetrated in all directions by feldspar, show in some cases cleavage faces over an inch in length. Spotting these cleavage surfaces are small yellow-green grains of olivine. Considerable black ore material and a little pyrite can also be made out under the lens. After the rock was pulverized the black ore material was strongly attracted to a magnet and when dissolved in hydrochloric acid in presence of tin gave no titanium reaction.

The microscopical study was made on two sections from one of the bowlders near the bed of the stream. In both the diabase structure is typically developed, the lath-shape fe ldspars penetrating the other constituents in all directions. No evidences of disturbances are visible, except such as are explained by movements in the partially consolidated magma. There are present besides feldspar, augite, olivine, hornblende, biotite, ilmenite, apatite and clorite.

The feldspar is polysynthetically twinned according to both the ordinary laws, and is only moderately altered. Determinations by Michel-

Levy's or Pumpelly's method of measuring the extinction angle in those sections which give symmetrical extinctions (zone of $\bar{b}$), furnished a maximum value of 28°, making it probable that the feldspar is labradorite. A tolerably fresh piece gave a specific gravity of 2.695. Some crystals show a decided cloudiness, which is found to be due in part at least to the formation of a colorless micaceous mineral.

The augite, which is penetrated in all directions by plagioclase laths presents some interesting characters. The usual cleavage parallel to the prism is well marked with good partings parallel to one or both of the vertical pinacoids. In some basal sections all four of these are well developed. The color of the mineral is reddish to yellowish-brown, but with varying depth of tone, and sometimes grades into an olive near the periphery of the section. The dichroism of basal sections is most marked, the ray vibrating parallel to the plane of symmetry, being yellow-brown with a slight tinge of red, and that vibrating in the perpendicular direction being distinctly red-brown. The monoclinic symmetry of the mineral is evinced by the inclined optic axis always obtained in sections which show nearly perpendicular cleavages, and by the high extinction angles (as high as 45°) in those sections which show but one cleavage. A brown or greenish brown hornblende is sometimes found as a partial peripheral zone about or inclosed within augite crystals, generally with approximately the same orientation as the augite. It appears to be original, its position being explained by parallel growth. The hornblende cleavage and the marked pleochroism serve to identify it. The pleochroism is $\overset{\shortparallel}{c}$ deep blue-green or brown, $\overset{\perp}{b}$ deep green or brown, and $\grave{a}$ light green or light reddish brown. The absorption equation is $c = b >> a$. In one of the two sections there is considerable green hornblende in good crystals, grouped about areas filled with more or less unresolvable material (probably both hornblende and chlorite and doubtless pseudomorphs after olivine crystals).

Olivine is present in one of the sections in crystals which are identified by their peculiar hexagonal outlines, colorless character, rough surface, parallel extinction, imperfect cleavage, and large optical angle in the plane perpendicular to the cleavage lines (base). In this section the mineral is in many cases remarkably fresh, showing along cracks, however, a small amount of a bluish green substance which is also to be found about crystals. There are also small, more or less irregular areas particularly abundant in the vicinity of ilmenite, which are in part red-brown and pleochronic and in part greenish. The brown parts are made out to be brown hornblende, and the green portions chlorite, in part of the variety known as delessite. The chlorite sometimes shows very marked pleochroism from intense orange to bluish green, and has slightly inclined extinction. It is clear from the disposition of the chlorite that it is the alteration product of the hornblende as well as of

the olivine, and it is probable that in some cases at least the hornblende is an intermediate stage, the alumina necessary for the alteration being obtained from feldspar. Cores of olivine are found in some crystals that are more than half altered. In the second of the two sections no olivine is present, but patches of more or less opaque green or brown substance indicate the position of the original mineral.

In both sections a little biotite is present in fresh blades which give the marked mottled appearance just before extinction between crossed Nichols. Apatite is abundant in crystals of moderate size, sometimes, though rarely, broken across. Fluid inclusions in the apatite are rare. Magnetite is quite abundant in large crystals which frequently show skeleton forms, and there is a little pyrite.

The rock is therefore a coarse-grained and feldspathic olivine diabase. Examination of a larger number of sections would quite likely add some characters to those that have been mentioned. The presence of a talcose mineral in the decomposed rock observed at the locality is not explained by examination of the sections. It doubtless arises mainly from a profound alteration of the pyroxene constituent, which in the sections is almost unaltered.

ON THE DEEP WATER CRUSTACEA OF GREEN LAKE.

By C. DWIGHT MARSH.

During the past two seasons I have become interested in the deep water fauna of Green Lake, and have made a large number of collections. While the results may not be particularly striking, I think they are of sufficient interest to warrant the presentation of a short paper on the subject. Because of its depth, Green Lake resembles, in the conditions controlling animal life, the larger bodies of water, and might be expected to have a fauna somewhat different from that of the shallower lakes. My collections seem to justify this expectation.

It is only within a few years that it has been deemed worth while to make any investigation of the fauna of deep water. Even after the existence of a very rich pelagic fauna in the oceans was recognized, bodies of fresh water were almost entirely neglected. Now, it is well known that our lakes have a pelagic fauna rich in individuals, if not in species, and a less abundant abyssal fauna. Most of the European lakes have been explored with more or less thoroughness. Especially noticeable is the extended work of Prof. Forel upon Lake Geneva and the smaller Swiss Lakes.

In this country comparatively little has been done. Since the initiatory work of Dr. Hoy in Lake Michigan, some twenty years ago, so far as I know, only two persons have published anything on this subject — Prof. S. I. Smith, and Prof. S. A. Forbes.

The bottom of Green Lake, in the deeper parts, is a fine blue clay, in which are great numbers of ostracod shells and some few shells of molluscs. I submitted the molluscs to Mr. C. T. Simpson of the United States National Museum, who tells me that there was nothing of especial interest among them. They were all littoral forms, and, in most cases, probably washed in from shallower water.

There were also several species of hydrachna, worms, and infusoria, which I have not worked out. The crustacean fauna is extremely abundant, although the number of species is small.

The following species were noted:

Diaptomus sicilis Forbes.
" *minutus* Lillj.
Epischura lacustris Forbes.
Limnocalanus macrurus Sars.
Cyclops fluviatilis Herrick
" *serrulatus* Fischer.
Canthocamptus sp.
Cypris sp.
Daphnella brachyura Baird.
Ceriodaphnia reticulata Jurine.
Daphnia kalbergensis Schoedler.
Bosmina sp.
Alona glacialis Birge.
Leptodora hyalina Lillj.
Pontoporeia Hoyi Smith.
Mysis relicta Loven.

There were, besides, several forms of *cyclops*, which seem to differ fron any described American species. As I am now engaged in a study of thi genus, I will leave their description for a later publication. None of th species of cyclops which I have found is peculiar to the deep water, as have found the same forms in the littoral zone of the lake, and in smalle bodies of water in the vicinity.

The pelagic fauna consists mainly of the following species: *Diap tomus minutus* Lillj; *Diaptomus sicilis* Forbes; *Epischura lacustri* Forbes; *Limnocalanus macrurus* Sars; *Daphnia kalbergensis* Schoedler *Leptodora hyalina* Lillj. All of these, with the exception of *limnocalanu macrurus*, come to the surface at night. The species of *cyclops* are repre sented very sparingly, and *canthocamptus*, *daphnella*, *ceriodaphnia*, an *alona* are quite rare. Evening collections showed vast numbers o *diaptomus minutus* and *epischura lacustris*, and in some cases of *lepto dora hyalina*. I found *bosmina* very abundant in November, but rathe rare in the summer months. The *abyssal crustacea* are *cypris*, *ponto poreia Hoyi* Smith, *mysis relicta* Loven, and perhaps some of the form of *cyclops*. Especial interest, perhaps, attaches to three species of th preceding list.

Diaptomus minutus Lillj. is found in great numbers, being muc more abundant than *diaptomus sicilis* Forbes. My specimens corre spond very closely to the description by Lilljeborg, as given in "Revis ion des Calanides d'Eau Douce," by Guerne and Richard, differing onl in the following particulars. The joints of the right fifth foot of th male are shorter and stouter, and the terminal claw is longer and some what more slender; the lateral spine on the last joint is blunt. Th inner ramus of the left foot is more nearly elliptical. The animal ave

ages somewhat smaller than the type. These differences are so minute that I consider them only varietal, although they are constant in the specimens I have examined.

Diaptomus minutus has been found, hitherto, only in Greenland and Newfoundland, although it seems probable that it is widely distributed over the northern part of North America.

Pontoporeia Hoyi Smith, has been found, hitherto, only in Lake Superior and Lake Michigan. A species almost identical with it, *pontoporeia affinis* Kroyer, occurs in the abyssal fauna of the Scandinavian lakes.

Mysis relicta Loven, was first found in the Scandinavian lakes. It is so closely allied to *mysis oculata* Kroyer, a marine form found off the coast of Labrador and Greenland, as to be considered only a variety of that species. It was found in Lake Michigan by Dr. Hoy, receiving the name of *mysis diluvianus* from Prof. Stimpson. Later, Prof. S. I. Smith collected specimens in Lake Superior. I have not had an opportunity to compare my specimens with those from the Great Lakes, or with the original description of the Scandinavian form, but I have little doubt that they are identical with them.

When we compare the deep water crustacea of Green Lake with those of Lake Michigan and Lake Superior, as shown in the lists published by Prof. Smith and Prof. Forbes, we find a striking similarity. That this should be true of the pelagic fauna is not strange, for it is easy to explain the migration of such forms from one body of water to another through the agency of water fowl.

The presence of *pontoporeia Hoyi*, and *mysis relicta* however, is not so easily explained. They are abyssal forms, found only in deep water, and never coming to the surface. Their presence in the Scandinavian lakes is explained by supposing that the bodies of water, in which they are found, were formerly connected with the sea, and that, when the access of salt water was cut off, the change to fresh water was so gradual that the animals accustomed themselves to their new conditions of existence. They belong to the "fauna relegata" or "relickten-fauna" of the Germans. This explanation does not seem to apply to Green Lake. The lake is of glacial origin, a dam of drift at the western end preventing its waters from flowing into lake Puckaway. The outlet of the lake is a small stream flowing through the village of Dartford, and emptying into the Fox River. So far as I know, there is no geological evidence whatever of any connection of Green Lake with either the Mississippi Basin or the Great Lakes, by which these deep water animals could have migrated to their present location.

The problem is one for which I can at present offer no solution.

NOTES ON DEPTH AND TEMPERATURE OF GREEN LAKE.

By C. DWIGHT MARSH.

Green Lake is situated in Green Lake county, and is something over seven miles in length, and rather less than two miles in its greatest breadth. It extends in a northeast and southwest direction, and is considered by geologists, to be of glacial origin, its shores at the western extremity being formed of drift hills.

The lake is of especial interest because of its depth, it being, I think, the deepest lake within the limits of the state.

While at various times soundings have been made by which the deepest parts of the lake were located with a fair amount of accuracy, the only attempt at systematic soundings was made some years ago by Prof. C. A. Kenaston, when he was connected with Ripon college. Through the kindness of Mr. Henry Wolcott, of Ripón, I was enabled to get the results of Prof. Kenaston's work. The soundings were made in winter through the ice and the distances between stations chained off.

Four lines of soundings were made: from Bowen's cottage to Oakwood Hotel, from Sandstone Bluff to Oakwood, from Sandstone Bluff to Sherwood Forest, and from Sandstone Bluff to Sugar Loaf. The following tables give the results:

From Bowen's Point to Oakwood.

Distance.	*Depth.*
64 rds.	63 feet.
192 "	96 "
256 "	84 "
272 "	97 "
288 "	90 "
304 "	20 "
320 "	61 "
336 "	66 "
352 "	53 "
384 "	38 "
432 "	49 "
464 "	41 "
626 "	Shore.

From Sandstone to Oakwood.

Distance.	*Depth.*
27 rds.	52 feet.
43 "	89 "
59 "	144 "
75 "	160 "
91 "	160 "
155 "	151 "
267 "	88 "
315 "	27 "
363 "	25 "
395 "	48 "
427 "	22 "
491 "	Shore.

From Sandstone to Sugar Loaf.

Distance.	*Depth.*
48 rds.	75 feet.
96 "	136 "
144 "	160 "
208 "	180 "
320 "	190 "
560 "	195 "
720 "	180 "
752 "	152 "
816 "	40 "
896 "	Shore.

From Sandstone to Sherwood Forest.

Distance.	*Depth.*
40 rds.	150 feet.
64 "	160 "
100 "	159 "
196 "	140 "
256 "	132 "
292 "	73 "
316 "	15 "
348 "	Shore.

From these tables and the profiles derived from them, it will be seen that the eastern part of the lake is comparatively shallow, and that there is a bar not far from the center where the depth is only twenty feet. The greatest depth — 195 feet — is reached between Sandstone Bluff and Sugar Loaf.

I have made no attempt at systematic soundings, but, in connection with dredging, have always taken the depth at the time of the haul, and my figures agree in all respects with those of Prof. Kenaston, except that they are uniformly somewhat less; this is easily explained by the fact that the level of the lake has been lower than usual for the past two or three years.

In the western part of the lake but few soundings have been made by any one. Capt. Pierce tells me that the greatest depth he has found is 172 feet. It is popularly supposed that the deepest place is between Sugar Loaf and the south shore, as that is the last place to freeze. I have found there, however, only 189 feet.

It will be noticed that the littoral zone, in most parts of the lake, is very narrow, considerable depths being reached quite near the shore.

When dredging in deep water, I also took surface and bottom temperatures. This work was done in Aug., Sept., and Oct. 1890, and July, 1891. As, so far as I know, very little work of this kind has been done in our lakes, I have thought the results worth recording, although my observations were too few to form a basis for any general inferences.

For bottom temperatures, I used a Miller-Casella deep sea thermometer, loaned by the United States Commissioner of Fish and Fisheries, and for surface temperatures a common chemical thermometer. As the thermometers were not tested, the results may not be absolutely accurate. The deep sea thermometer was attached about two meters from the sounding lead, giving the "bottom temperature."

The following tables give the temperatures arranged by depths:

AUGUST, 1890.

Depth.	Surface tem.	Bottom tem.
17 meters.	25° C.	10.25° C.
24.5	25.	7.7
31.	26.	7.45
33.	24.	7.2
36.	25.5	7.2
40.5	26.	7.
40.85	25.	7.
41.5	24.	7.
42.	24.5	7.
42.2	24.	7.
43.	24.	7.
45.25	.....	6.6
46.75	24.	6.6
48.45	22.	6.6

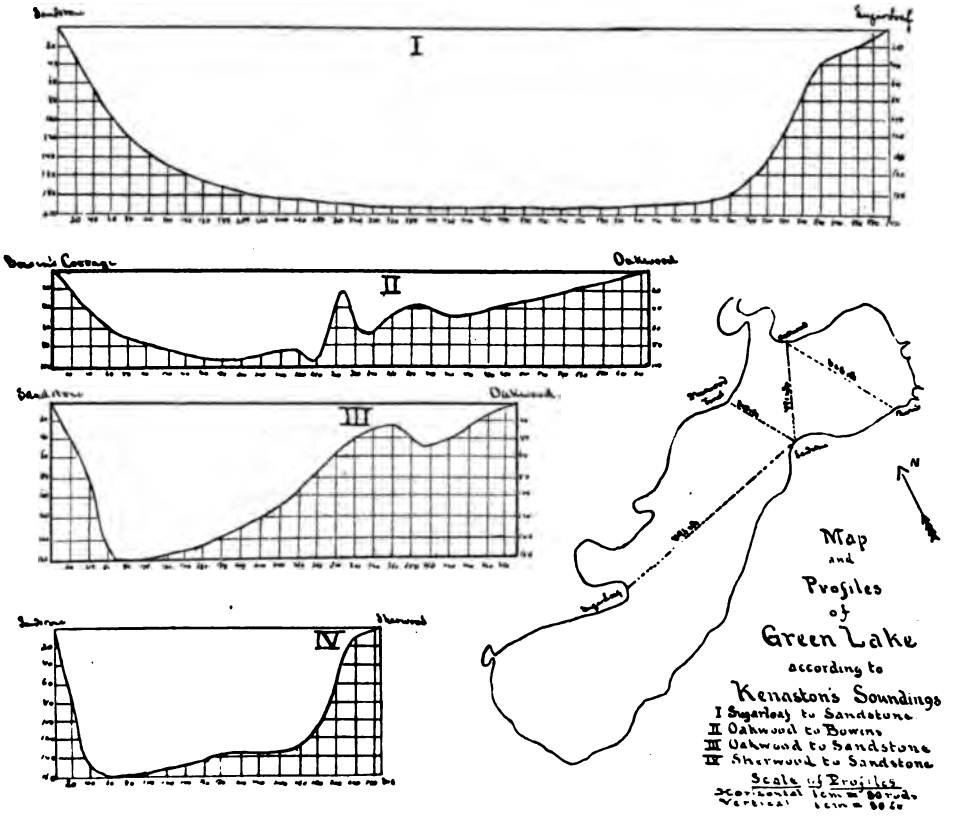
JULY, 1891.

Depth.	Air tem.	Surface tem.	Bottom tem.
41.85 meters.	22°.77 C.	21.° C.	5.4° C.
43.5	23.33	23.	5.56
50.	22.22	22.	5.28
50.5	25.	22.	5.28
51.2	20.55	22.	5.28
56.	21.11	21.	5.28
57.75	24.72	21.	5.28
58.	26.3		5.28

We notice that in August, 1890, there was a uniform temperature of 6.6° C. below a depth of 45 meters, and that up to 25 meters there was an elevation of temperature of only one degree. In July, 1891, the bottom temperature was 5.28° C. While we cannot compare temperatures taken in August, 1890, with those taken in July, 1891, I think we may fairly infer that the maximum bottom temperature in Green Lake is reached in August, and that it remains nearly the same during September and October. The surface temperature is nearly the same in all the deeper parts of the lake. Swimmers, in crossing the lake, claim that they pass through "streaks" of different temperatures, but the thermometer determinations show a practical uniformity of surface temperature.

In comparing these temperatures with those obtained by Prof. and Mrs. Peckham in Pine Lake (Trans. Wis. Acad. V, 273), I notice that

although the surface temperatures in Pine Lake, in both July and August, are higher than in Green Lake, the temperature of the deep water is nearly the same. For instance, in August, 1879, at a depth of 18.28 meters, the bottom temperature was 7.23° C., while the surface temperature at the same time was 24.44° C., and in July, at a depth of 24.38 meters, the bottom temperature was 5.56° C., and the surface temperature 26.12° C. Thus, at 24.38 meters, was reached very nearly the minimum temperature which I found in Green Lake at 50 meters and below.


I
II
III
IV
Oakwood
Sandstone
N
Map
and
Profiles
of
Green Lake
according to
Kenaston's Soundings
I Sugarloaf to Sandstone
II Oakwood to Bowins
III Oakwood to Sandstone
IV Sherwood to Sandstone
Scale of Profiles
Horizontal 1cm = 80 rods
Vertical 1cm = 80 ft

THE IRON ORES OF THE LAKE SUPERIOR REGION.

By C. R. VAN HISE.

The object of the present article is to bring together in a single paper the more important conclusions as to the iron ores of the Lake Superior region, which have been reached in recent years by the Lake Superior Division of the United States Geological Survey.

The iron ores are all associated with peculiar nonfragmental rocks which have great variety, but which have the common feature of containing a considerable content of iron. The varieties include ferruginous cherts, ferruginous slates, sideritic slates, actinolitic schists, magnetitic schists, hematitic schists and intermediate phases. At different times in the past it has been suggested that the Lake Superior iron ores, like many of those of later age, are derived from carbonate of iron. However, Irving was the first to definitely prove this by showing that in this region there is abundant residual iron carbonate, and that there are actual transitions between this and other phases of the iron formations.* Since this conclusion was announced, the evidence that these and also the ores are derived directly or indirectly from a lean cherty and often calcareous and magnesian siderite has been greatly augmented.

The manner of the transformation of the iron carbonates into the other phases of rock of the iron formation have been traced out in detail in the Penokee and Animikie districts.† The work of the past two years has given a large amount of evidence that exactly similar transformations have taken place in the Marquette, Vermilion, and Kaministiquia districts. As yet the Menominee proper and Felch Mountain districts have not been sufficiently studied to furnish this evidence; but the ferruginous rocks here occurring are exactly like those in the other districts and there is no doubt as to their equivalent age, so that it is highly probable that the same is true.

The iron ores now mined occur in two geological series, separated by a physical break.‡ These are the Lower Huronian and Upper Huronian.

* Irving, R. D., Origin of the Ferruginous Schists and Iron Ores of the Lake Superior region: Am. Jour. Sci., 3rd ser., vol. 32, 1886, pp. 255-272.

† Irving, R. D. and Van Hise, C. R.: The Penokee Iron-Bearing Series of Michigan and Wisconsin: Tenth Ann. Rept. U. S. Geol. Survey, 1890, pp. 380-422.

‡ Van Hise, C. R.: An attempt to harmonize some apparently conflicting Views of Lake Superior Stratigraphy. Am. Jour. Sci., 3rd ser., vol. 41, 1891, pp. 117-137.

In each there is one main iron-bearing formation both of which were originally of nearly the same character, and their subsequent transformations have been much alike. The chief differences are that hard specular hematite, magnetite, and the actinolite-magnetite-schists are more common in the older formation; while the soft hematites, limonites and cherts are more common in the newer formation. However, most phases of rocks and ores are found in both newer and older formations, the main difference being that of relative proportions.

As a consequence of the likeness of original characters and subsequent transformations it is possible to treat together the genesis of the ores of these two series.

A third horizon at which ore-bodies occur is at or near the base of the Upper Huronian. This formation is not continuous, it being present only when the base of the Upper Huronian chances to rest upon the iron-bearing formation of the Lower Huronian. Here the detritus has been largely derived from the immediately subjacent formation and is consequently rich in iron. As will be seen, a farther concentration of the iron oxides at this horizon has occurred at the same time as the concentration of the iron ores of the two main formations. At this third horizon are to be placed several of the important mines and certain of the ore-bodies of others of the mines of the Marquette district. The history of these deposits explains why they frequently occur adjacent to the ore-deposits of the Lower Huronian.

The Lower Huronian includes the Eastern Menominee, Felch Mountain, Lower Marquette, Vermilion, and Kaministiquia districts; and the Upper Huronian includes the Western Menominee, Upper Marquette, Penokee, Mesabi, and Animikie districts. It thus appears that in the Felch Mountain and Vermilion districts only the iron-bearing formation of the Lower Huronian is known, and in the Penokee and Mesabi districts only the iron-bearing formation of the Upper Huronian is known. In the Marquette and Menominee districts the iron formations of both series are represented, but the relations of the two are much more easily made out in the former than in the latter. The Kaministiquia and Animikie series also come together in a single district and the unconformable relations which here obtain are as clear as in the Marquette district.

As areas to serve as types we will first consider the Penokee and Lower Marquette series, the first belonging to the Upper Huronian and the second to the Lower Huronian. These are chosen because here the investigations have gone farther.

The Penokee ores.- In the Penokee district the iron-bearing formation comprising all the varieties of rocks above mentioned as belonging to this member, is on an average about 800 to 850 feet thick, but the iron ores are mainly confined to the lower 400 feet. The formation rests upon an argillaceous quartz-slate the uppermost horizon of which is a per-

sistent quartzite. It is covered by a great formation of clay-slates, graywacke-slates, etc. These formations constituting the Penokee series are a simple monocline, dipping northward from 50° to 80° (Pl. VII, fig. 1.) The series has been cut before tilting by numerous basic dikes nearly at right angles to the bedding, but in such a direction as to now make the outcrops of a dike and the iron-bearing formation form the two sides of an acute angle which usually faces to the east. The unaltered phase of the iron-bearing formation, i. e., the lean cherty carbonate of iron, is most frequently found immediatly under the overlying slate, which has protected this material from percolating waters, while near its base rarely is found this sideritic phase, it having here usually been decomposed. The intersections of the dike rocks and the quartz-slates form numerous right angled troughs tilted somewhat to the northward, (Pl. VII, fig. 2.) These generally have a pitch toward the east (Pl. VII, fig. 3), consequent upon the relations already described. But if the outcrop of the dike is parallel to that of the ore formation the ore-deposit will have no pitch, while if the outcrops of the dike and quartz-slate form a westward-facing acute angle the deposit will have a pitch toward the west.

Now, with few exceptions, the ore-bodies of the entire Penokee district occur at the apices of these troughs (Pl. VII, figs. 2 and 3), having roughly a triangular section or a V shape the lower part of which is relatively heavy and pitching with the altered underlying diabase dikes, usually called by the miners "soapstone." The boundaries of the ore formation are usually sharp along the dike-rocks and the quartz-slate, but vary upward often by imperceptible stages into the ferruginous rocks of the iron-bearing formation. It follows from the above that each ore-deposit may be traced to the surface in one direction,and in the other direction will pass deeper and deeper. It is not uncommon for one dike some distance below another dike to also carry an ore-body. In this case a shaft will pass through its first ore-body, its basement dike and a greater or lesser thickness of lean ferruginous material, when another ore-body, resting upon another dike will be found (Pl. VII, fig. 3). This latter body may have been previously discovered at or near the surface at some point east or west of where the uppermost body reaches the surface and therefore ceases. In other cases the dikes may be so close together as to have the entire space between them filled with ore. In still other cases more than two dikes bearing ore-bodies have been found in vertical section.

Summing up, the Penokee ore-deposits are then roughly triangular in cross section. They usually pitch to the east. They rest upon impervious formations below, and generally grade upward into a porous ferruginous chert or slate of the iron formation.

The Lower Marquette Ores.—In the Lower Marquette * series the ores have somewhat greater variety of occurrence. The deposits, instead of

* Van Hise, C. R. The Iron Ores of the Marquette district of Michigan. Am. Jour. Sci., 3d series, vol. 43, 1892, pp. 116-132.

being for the most part at the base of the iron-bearing formation, are either within this formation or at its upper part; that is, just below the base of the Upper Huronian. The formation above the iron-bearing formation is a quartzite grading downward into a conglomerate, the material of which, is largely derived from the subjacent Lower Huronian series. The iron-bearing formation is cut by numerous dikes at various inclinations and by great bosses of basic eruptives. These latter sometimes break across the bedding of the iron formation, at other times the intrusives bow the bedding upward so as to make the formation dip away from the greenstone ridges. Not in frequently a ridge of eruptives forms a more or less complete semicircle, the iron formation constituting a valley within it.

Now, the ore deposits are found either at the contact plane between the Upper and Lower Huronian, or else they rest upon or along the eruptives (Pl. VII, fig. 4); when fresh called diorite, when altered called soapstone. The dikes may be vertical or inclined. One may be alone or two or more may be adjacent. The greenstone bosses may have a uniform dip or may be folded so as to form a complete synclinal trough (Pl. VII, fig. 5). A dike may unite with a larger greenstone mass to form a trough (Pl. VII, fig. 6). Whether the ore deposit rests upon a wall, a synclinal or an irregular trough of eruptive rock, the body is not horizontal, but following the greenstone, pitches at an angle of 20° to 40° or even more. As in the Penokee district, the ore-deposits have an abrupt termination at the underlying eruptive rocks and grade upward somewhat gradually into the chert and jasper. In the case of those ore-deposits which are at the contact of the Upper and Lower Huronian, the bodies usually occur at places where the ore formation has been sharply shattered or bent; or where an intersecting intrusive serves as an impervious basement; or where both are combined. Such deposits may terminate abruptly along a joint or may grade into the chert or jasper (Pl. VII, fig 7).

While the Marquette ore-deposits may rest upon formations of different characters, and may vary greatly in shape, in common with those of the Penokee district, they lie for the most part upon impervious formations in pitching troughs, and grade above into the broken and porous material of the ore formation; or, if at the contact horizon, into the recomposed ore formation of the Upper Huronian.

Ores at base of Upper Marquette series.-- The contact deposits of the Lower Huronian may continue upward into the Upper Huronian, a single ore-body belonging in part to the Lower Huronian and in part to the Upper Huronian, when the two series, although unconformable, are welded together by subsequent infiltrations, as a consequence of which the non-fragmental iron formation of the Lower Huronian appears to grade up into the mechanical sediments of the Upper Huronian. In other places the ore-deposits near the contact plane may lie wholly within the Lower Huronian or wholly within the Upper Huronian. In

the latter case this may be sometimes due to the fact that erosion has removed all or nearly all of the Lower Huronian iron-bearing formation The ores above this contact plane, like those already considered, are frequently adjacent to or underlain by subsequent intrusives which serve as impervious basement formations.

The ores adjacent to the contact plane include the magnetites of the Marquette district. Those belonging to the Lower Huronian have a somewhat different aspect from those of the Upper Huronian. This is due to the extraneous mechanical detritus of the latter. In thin section it is often found that more or less mica has developed. In examining the structure of the ore-deposits, it is seen that much of the magnetite is in veins or cavities in finer grained and partly or wholly original material. An examination of thin sections of the overlying magnetic quartzites and conglomerates shows conclusively that much of the magnetite is a secondary infiltration.

Ores of other districts.— It is unnecessary to give the details of the occurrences of ores in other districts, but it may be said, while the character of the bounding formations may be somewhat different, that the ore-deposits as in the Penokee and in the Marquette districts rest upon formations which are impervious. These may be fragmental slates, contemporaneous surface volcanics, or subsequent intrusives. Also any one of these, or two of them, may combine to form a pitching trough. And even in the cases in which there is but a single impervious wall upon which the ore rests, it is usually found that the deposit has a pitch. The ore-bodies usually grade above into the other phases of rock of the iron-bearing formation, as in the Penokee and Marquette districts.

In the Western Menominee district the ore-bodies very extensively rest upon surface volcanics which appear to be here the inferior formation of the Upper Huronian series. In both the Upper Menominee and the Upper Marquette ores are also found resting upon the slates. In some cases these underlying slates have a monoclinal dip as in the Penokee district, and in others are folded into pitching synclinals. The iron-bearing horizons of these districts do not appear to be continuous belts of pure iron formation materials as is that of the Penokee. They are often but sideritic phases of the great slate formation of the Upper Huronian. Where this slate becomes usually sideritic and the other conditions explained as requisite occur together the concentration of ore-bodies has taken place.

In the Vermilion district the ore-bodies commonly rest upon impervious schists believed to be greatly modified volcanics or upon intrusive massive greenstones of later age. Not infrequently one or both of these combined form pitching troughs.

In the newly developed Mesabi range the ores, according to Mr. Merriam, are near the base of the series resting upon a quartzite which

lies unconformably upon impervious green crystalline schists of the Archean complex. They are overlain by a slate or shale of great thickness. They have a gentle dip to the southward. In certain respects they are like the Penokee deposits. Whether the bodies will be found in pitching troughs, it is yet too early to say.

Genesis of the ores.—The peculiar forms and relations of the Lake Superior iron ores exclude a large number of explanations which have been advanced for the genesis of these deposits. It is evident that in their present position they are not eruptives. Even if it be argued that the iron-bearing formations are igneous it would hardly be held that these peculiar ore-bodies are of direct intrusive origin. The forms which these bodies have are wholly unlike those of intrusive rocks. Instead of being continuous downward as such rocks should be they usually terminate below upon igneous rocks. It is equally plain that the ore-deposits are not of direct sedimentary origin, although it is believed that the formations containing them, and from which they are derived are sedimentary. We know of no way by which sediments could be deposited in such irregular forms as these. Also their frequent connection with subsequent intrusive rocks shows that between the ore-deposits and the latter there is some genetic connection. Although by the miners the ores are often spoken of as veins, these deposits have never been seriously regarded as fissures, nor can they be regarded as deposits which have filled caves.

All of the evidence plainly points in one direction, that is, that they are concentrations produced by downward percolating water. These waters removed a part of the original material of the iron-bearing formations at the places where the ore-bodies occur and introduced iron oxide nearly simultaneously. This explains the forms, positions and relations of the ore-deposits. They rest upon tilted walls or troughs of impervious formations because water has here been converged. They occupy places once taken by a part of the ore-formation because this is readily penetrated by water, because it was rich in iron carbonate, and because the constituents other than iron oxide are readily soluble.

The original condition of the ore-formation, as has been said, is a lean sideritic and cherty slate. In order that the ore-bodies should be formed, silica must have been removed and iron oxide introduced. That this interchange has actually occurred is shown by an examination of the iron-formation rocks associated with the ore-bodies. It has been noted that the change from the ore-bodies to the rocks above is a transition rather than abrupt. Along this transition zone it is a common thing to see silica bands die out by gradual removal. In the iron formation proper the silica is frequently in nearly solid bands, alternating with bands richer in iron. In passing toward the ore, cavities appear in the rock, the silica being removed so that the stratum is here a porous one. The cellular or geodal cavities formed by the removal of silica are very characteristic

of this transition zone and even when so minute as not to be visible in the hand specimen are discoverable by a microscopical examination. However, before all of the silica is removed, iron oxide begins to be introduced, and finally when the interchange is complete, in the places of the siliceous bands is a solid body of iron ore.

It is usually found that the eruptive rocks underlying the ore-bodies are greatly altered, the alkalies having been removed. It is probable that these alkalies have been an important agent in the solution of the adjacent silica. It is evident that the pitching troughs are places along which abundant water must travel because the surface waters are not able to penetrate the underlying formation, and the overlying formation is a porous one. It is equally evident that the contact plane between the Upper and Lower Huronian, where there is a coarse conglomerate at the base of the Upper Huronian, is also a horizon along which underground waters travel, and this is particularly true where violent folding has shattered the underlying ore-formation, and here it will be remembered the ore-bodies of this horizon usually occur.

Along these channels of percolation, as in the case of fissures, waters from various sources meet. A portion of these waters will have traveled for a considerable distance through the iron carbonates. Such waters will have oxidized this iron carbonate in part and thus become carbonated and take other iron carbonate into solution. Such iron-bearing waters will meet along the impervious formations other waters which have reached these positions by shorter paths, traveling perhaps wholly through already altered and brecciated ore-formation material containing no iron carbonate. Such waters carrying no iron, but containing oxygen, will precipitate the iron from the carbonated solutions.

Those ore-bodies which underlie one or more impervious formations, but rest upon other impervious formations have derived their material from the areas of iron formation material between the dike or other basement formations of the ore-bodies in question and those of the next overlying deposit. In a given instance this part of the ore-formation will have a considerable surface area for the entrance of percolating waters between the outcrops of the underlying and overlying impervious formations. (See Plate VII, fig. 3.) The waters have here carried the iron oxide along the impervious formation upon which the ore rests and have precipitated it under the overlying impervious body. Whether the ore-body thus produced fills the entire space between the two impervious formations depends upon the supply of material which was available and upon the perfection with which the process of concentration has been carried out.

In the production of the magnetic ores it appears that there was not a sufficient amount of oxygen to peroxidize the iron, although there was

enough to precipitate it or a part of it at least. Pyrite associated with the magnetite indicates the presence of actual reducing agents and these may have changed some of the original hematite of this horizon to the form of magnetite. This lack of oxygen at the plane separating the Lower and Upper Huronian may be due to the fact that immediately above is the impervious slate of the latter; consequently from the surface there was no direct path for percolating waters.

From what has been said as to the transition zone between the ore-bodies and the iron formation, it will be seen that the process of the solution of the silica often runs in advance of the introduction of the iron oxide. It is wholly possible that the silica has been sometimes removed so far ahead as to cause a considerable sagging of the ore-formation. This suggestion is made because the brecciated character of the rocks adjacent to the ore-bodies frequently indicates that local fractures have occurred.

Many of the intrusives which cut the ore-formations are probably of Keweenawan age. If this be true it is evident that the concentration of these ore-deposits has occurred since Keweenawan time. It is also manifest that the final concentration did not occur until the folding and erosion subsequent to both the Lower and Upper Huronian series, and for a part of the districts at least these were post-Keweenawan. It is almost certain that the Lower Huronian iron formation was extensively modified before the Upper Huronian series was deposited, but it is also probable that the ore-bodies now mined have been produced simultaneously with those of the Upper Huronian, otherwise the Lower Huronian ore-deposits would not invariably be found above the eruptive rocks with which they are in contact. While the final concentration did not begin until the later foldings to which these series have been subjected, there is no evidence that the process has ceased at the present time.

The ore-bodies at the base of the Upper Huronian were concentrated in the lean detritus of the Lower Huronian iron formation at the same time and in the same manner as the ore-deposits just considered.

The remarkable likeness of the Upper and Lower Huronian ore-formations is then explained to be due to the likeness of the original iron-bearing formations of the Upper and Lower Huronian, and to the fact that the concentration of both was due to the same causes operating at the same time.

The Huronian rocks of Lake Superior are often spoken of as the iron-bearing series. The foregoing discussion shows that ore-bodies occur only in certain definite formations which constitute but a small percentage of the entire Huronian series. Moreover it is evident that valuable ores are only found within these formations where a combination of peculiar conditions occur causing local concentrations of iron oxide. A

recognition on the part of practical mining men of these principles will save large sums of money annually spent in unscientific prospecting, and, as they have already done in certain cases, will undoubtedly lead to the discovery of additional ore-bodies.

U. S. Geological Survey,
Lake Superior Division,
MADISON, WIS., March 7, 1892.

DESCRIPTION OF PLATE VII.

Fig. 1. Cross-section of Penokee series. Showing its relations to the underlying Archean, the overlying Keweenawan, and the conformable succession of its three members.

Fig. 2. Cross-section of Pence mine, Penokee series, showing the relations of the dike-rock, quartzite, ore-deposit, and drift material.

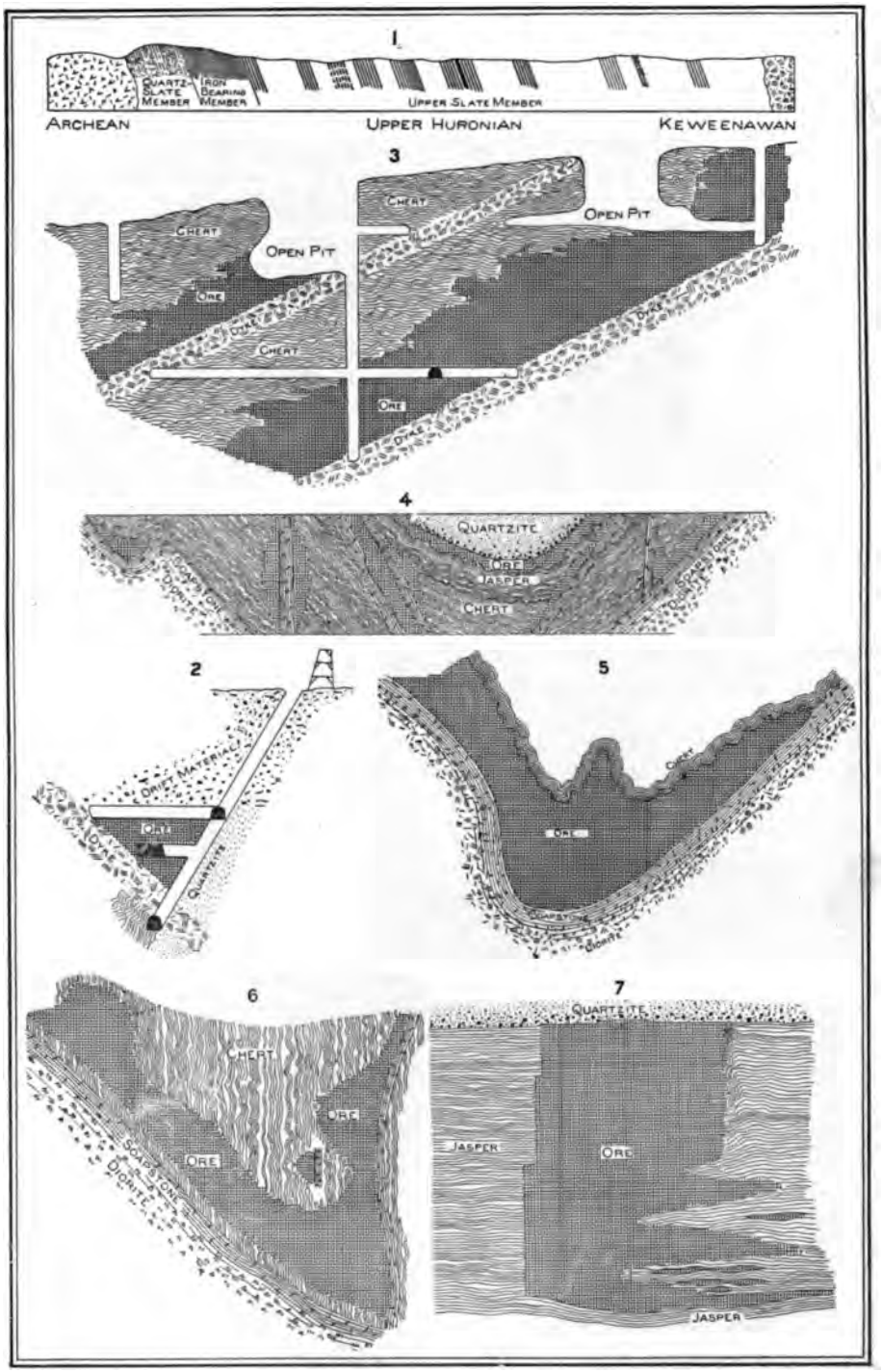
Fig. 3. Longitudinal section of a Penokee deposit, looking south. The figure shows how, as a consequence of the pitch of the dikes, the ore-bodies which reach the rock surface soon pass under the furruginous chert. The figure also shows, when one dike is parallel to another or nearly so, that the ore-body of the lower dike may pass under that of the upper. The vertical distance between the two deposits depends upon the horizontal distance between the outcrop of the two dikes and upon their pitch. The irregular way in which the ore passes above into the chert is seen, as well as a horse of rock at the west end of the west open pit.

Fig. 4. Generalized section of Lower Marquette ores, showing the relations of the deposits to the associated formations. Ore is seen at the contact of the Upper and Lower Huronion, above a folded mass of diorite, upon one or both sides of intersecting dikes, and in a trough formed by the union of a dike and a mass of diorite.

Fig. 5. Vertical cross-section of an ore-deposit of the Marquette district. This is bounded below by a synclinal of soapstone grading into diorite and above by ferruginous chert. The change from ore to chert is not so sharp as drawn. In longitudinal section this body shows a considerable pitch.

Fig. 6. Vertical cross-section of an ore-deposit of Marquette district. At the left the ore rests upon soapstone grading into diorite. At the right it is upon one side of a dike-rock, the latter being an off-shoot of the diorite. At the contact of the two a pitching trough is formed in which the ore-body becomes of large size.

Fig. 7. Horizontal section of ore-deposit on east side of Republic horseshoe, Marquette district. The left side of the ore is bounded by a cross joint. The right side is bounded in part by a sharp flexure passing into a joint, and in part grades into the lean banded jasper and ore.



ORE DEPOSITS OF LAKE SUPERIOR REGION

THE PRESENT CONDITION OF THE LATITUDE PROBLEM.

By G. C. COMSTOCK.

[ABSTRACT.]

The title which has been announced for my paper, "The Present Condition of the Latitude Problem," imposes upon me the necessity of explaining in what the latitude problem consists, since I can not assume that the term thus employed will be well understood even in scientific circles.

There come down to us from remote antiquity legends, curious enough in themselves, which seem to imply that at the time of their origin a very different condition of affairs obtained from that which now exists. Thus the early Egyptian temples appear to have been oriented with reference to the points of the compass at times when those points were different from what they now are, and there are traditions of a time at which the sun rose in the west and set in the east. And coming down to much more recent dates, speculation has been rife as to whether the great pyramids in Egypt may not contain in themselves evidence of a changed position of the earth's rotation axis.

Until within the last half dozen years such matters were looked upon by astronomers with the utmost incredulity, and it was almost a matter of faith that the earth's axis is the one thing terrestrial which is permanent in position. But about a half dozen years since Dr. Kuestner, one of the astronomers connected with the observatory at Berlin, undertook a very extended and accurate series of latitude determinations at that place, having in view as the object to be attained the solution of a very different problem, the determination of the so-called "constant of aberration." But Kuestner's results for the aberration came out wrong; they would not agree with the classical values of this quantity elsewhere determined, and he found himself face to face with the alternatives that either his observations were hopelessly bad, or that the latitude of his observatory had changed to the amount of nearly half a second during

the time covered by his observations. Kuestner adopted the latter alternative, but his suggestions were received with great incredulity on the part of astronomers, and it was only when it became apparent that similar changes could be traced in simultaneous observations elsewhere that the matter seemed worthy of serious investigation. Such investigation it has received under the auspices of the International Geodetic Association, which has for over two years past maintained a continuous series of observations at three German observatories, which agree in indicating a variation of the latitude of these stations in character entirely similar to that detected by Kuestner. In our own country similar investigations have been prosecuted in a less systematic manner, but agreeing nevertheless with the results of the German work.

But we come here to a new phase of the matter. An extended and very elaborate discussion of long series of astronomical observations running back over a period of more than a century has been undertaken by Mr. S. C. Chandler, who has reached the very remarkable result that during this entire period traces of a similar variation in latitudes may be detected, that is, that during this period the latitude of any given place on the earth's surface, instead of being absolutely fixed, has oscillated about a mean value, being at times a little greater and at others a little less than its average amount.

If we inquire into the causes of such an instability of latitude, we shall find very serious difficulties in the way of any explanation based upon known dynamical laws. It is true that Euler pointed out a century ago that if the axis about which the earth rotates does not coincide exactly with its axis of figure, that is the short diameter of the spheroidal earth, there will necessarily result a rotation of one of these axes about the other producing a slight periodic change in latitudes, and that this change should run through its complete cycle in a period of 306 days But it seems difficult at first sight to identify this theoretical oscillation with the actual changes detected by the European observers and by Mr. Chandler. The work of the European observers appeared to indicate an oscillation of latitudes having a period of very approximately a year, while the time required for the periodic change detected by Chandler is 427 days; so that the periods appear to be entirely discordant. A suggestion has been made in this connection, however, by Professor Newcomb which may help to bridge over the difficulty of co-ordinating these periods among themselves. He points out that the period of 306 days which is associated with Euler's name has been computed upon the supposition that the earth is a perfectly rigid body, while we have abundant evidence that the earth's rigidity, although great, is by no means infinite, and this lack of perfect rigidity will have the effect of lengthening the Euler period, so that it may be made 365 days or 427 days long, thus possibly bringing it into agreement with the observed periods. One difficulty

however, stands in the way of this explanation. Mr. Chandler has indicated as a result of his investigation that the period of time within which the latitude makes a complete oscillation is not of uniform length but ranges from about 350 up to 427 days, and this variation in the length of the period is in no way accounted for by Newcomb's explanation.

Turning now for a moment aside from this periodic variation of the latitude, let us briefly consider another but allied phase of the same matter. At the conference of the International Geodetic Association, held at Rome in 1884, Fergola, an Italian astronomer, presented a considerable amount of data tending to show that during the past century there had been a progressive diminution in the latitudes of European observatories. In other words, that aside from this periodic variation of latitudes there had been a steady and uniform drift of the surface of the earth in Europe away from the north pole. Fergola's paper attracted great interest at the time, and his suggestion that a concerted plan of action should be adopted for the systematic investigation of this secular change in latitude was adopted by the Geodetic Association. Measures were taken to have a series of observations for this purpose commenced at Washington and at Lisbon; but unfortunately the matter terminated without anything having been accomplished and the plan for systematic investigation seems to have been abandoned.

At the earnest request of some geologists especially interested in glacial phenomena, I took up the question of the secular variation of latitudes anew some three years ago, with the intention of examining more carefully the American data, which had scarcely been touched upon by Fergola, and of ascertaining whether it could be made to yield any contribution to a better knowledge of the secular change. Without going into the details of this investigation, it may suffice to state here that this data, although somewhat scanty in amount, still indicates very strongly that American observatories have a common motion toward the north pole amounting to about four feet per year; in other words, that the rotation axis of the earth, instead of being fixed relatively to the crust of the earth, is changing its position, moving in a direction along the west coast of Greenland, so that it is being brought progressively nearer to American stations and carried more slowly away from European ones. The results of this investigation were presented last summer to the American Association for the Advancement of Science, and a committee of that association was appointed to devise means for further investigation of these changes in latitude, both periodic and secular. Under the auspices of the International Geodetic Association, simultaneous observations are now being made in Germany and in the Hawaiian Islands. These will suffice for a very accurate determination of the periodic changes of latitude, but they are not well adapted to a determination of the secular change, the longitudes being badly chosen for this purpose,

and it is very much to be desired that as soon as possible a series of observations having the secular change in view should be undertaken in the United States and along the eastern coast of Asia, since the direction of the motion of the pole appears to be such that stations thus located will be subject to larger variations of latitude than those in any other longitudes.

ON THE CORRELATION OF MORAINES WITH RAISED BEACHES OF LAKE ERIE.*

By FRANK LEVERETT.

The narrow ridges of sand and gravel which traverse the plains of the western Erie basin, at distances varying from a few miles up to 80 miles or more from the present shore of Lake Erie, as well as those of the eastern portion of the Lake Erie basin, which lie near the borders of the lake, were recognized by the early settlers as old lake shores, and were known in many sections as "lake ridges." Nearly all the reports of geologists, whose work has lain within the territory covered by these beach lines, contain references to the beaches, and many contain valuable data concerning them, but so far as I am aware no complete tracing of any one of the beaches has been made by my predecessors.

At the time the reports of the Ohio geological survey were written, the question seems not to have been raised as to whether the beaches completely encircle the lake, though Dr. Newberry and Prof. Winchell each entertained the hypothesis that the high stage of water in the lake may have been caused by the occupancy of the present outlet of the Great Lakes by the retreating ice-sheet.† During the twenty years that have elapsed since these reports appeared, critical investigation of certain districts has shown that these beaches do not in all cases surround the bodies of water which they border. To Mr. Gilbert especially are we indebted for the advancement of knowledge along this line. The discovery was made by him, some years ago, that several of the raised beaches of Lake Erie do not completely encircle that body of water, but that those along its south shore terminate in a successive series from higher to lower in passing eastward from northern Ohio to southwestern New York. The results of his study are unpublished, but through his kindness I have been made acquainted with his recent views and supplied with the principal data. In explanation of the failure or disappearance of these beaches, in the eastern portion of the basin, Mr. Gilbert has entertained the theory that their eastern termini represent suc-

* The article from which the main part of this paper is taken appears in full in the American Journal of Science, Vol. XLIII, April, 1892.

† Geology of Ohio, Vol. I., p. 552; Proc. Amer. Ass. Adv. Sci., 1872, p. 183.

cessive positions of the ice front in its northeastward retreat across the Lake Erie basin, but has held that the complete verification of this theory depends upon the occurrence of moraines which are the demonstrable correlatives of the beaches. It is believed that such moraines have now been discovered and traced into connection with the three beaches which terminate in Ohio. Two other beaches terminate in southwestern New York, but since the glacial phenomena of that region have not received critical attention, it is not known whether moraines occur there which can be correlated with the beaches. The limitations of the several stages of the lake, on its north shore, have not been determined. The study is, therefore, far from complete and the present paper furnishes but a brief introduction to the interesting history which further investigations promise to reveal.

The facts to be presented are naturally grouped under three heads: (I) The Van Wert or Upper beach and its correlative moraine, the Blanchard ridge; (II) The Leipsic or second beach and its correlative moraine; (III) The Belmore, or third beach and its correlative moraine. The names here adopted are those suggested by Prof. N. H. Winchell.*

I. THE VAN WERT OR UPPER BEACH AND ITS CORRELATIVE MORAINE.

(a) *The Van Wert or Upper Beach.*—The distribution of this beach in Ohio and Indiana, and the southwestward outlet of the lake which it bordered, are well shown in maps published many years ago by Mr Gilbert.† It was supposed by Mr. Gilbert, at that time, that the beach continued further east than Findlay, and his maps accordingly contain a hypothetical continuation along the north slope of the Blanchard moraine to the Sandusky river at Tiffin. It is now found that there is a beach line having about the position conjectured by Mr. Gilbert, but it is the Leipsic or second beach, while the Van Wert or upper beach apparently terminates at Findlay, there being in the district east from the meridian of Findlay no beach line outside (south) of the Leipsic beach. At its eastern terminus, the beach is in the midst of a plain that rises gradually toward the north, the east, and the south, so that the lake terminated in a mere point whose waters were quite shallow. Along the Blanchard moraine, on the north side of of the river, there is no beach line of corresponding age with the Van Wert ridge, though sand sets in on the outer slope a short distance west from Findlay and reaches altitudes as great as on the beach south of the river. The phenomena along the moraine, as shown below, seem to indicate that the ice-sheet overhung it while the lake was still occupying the Van Wert beach, and thus prevented the waves of the glacial lake from making their impress on the moraine.

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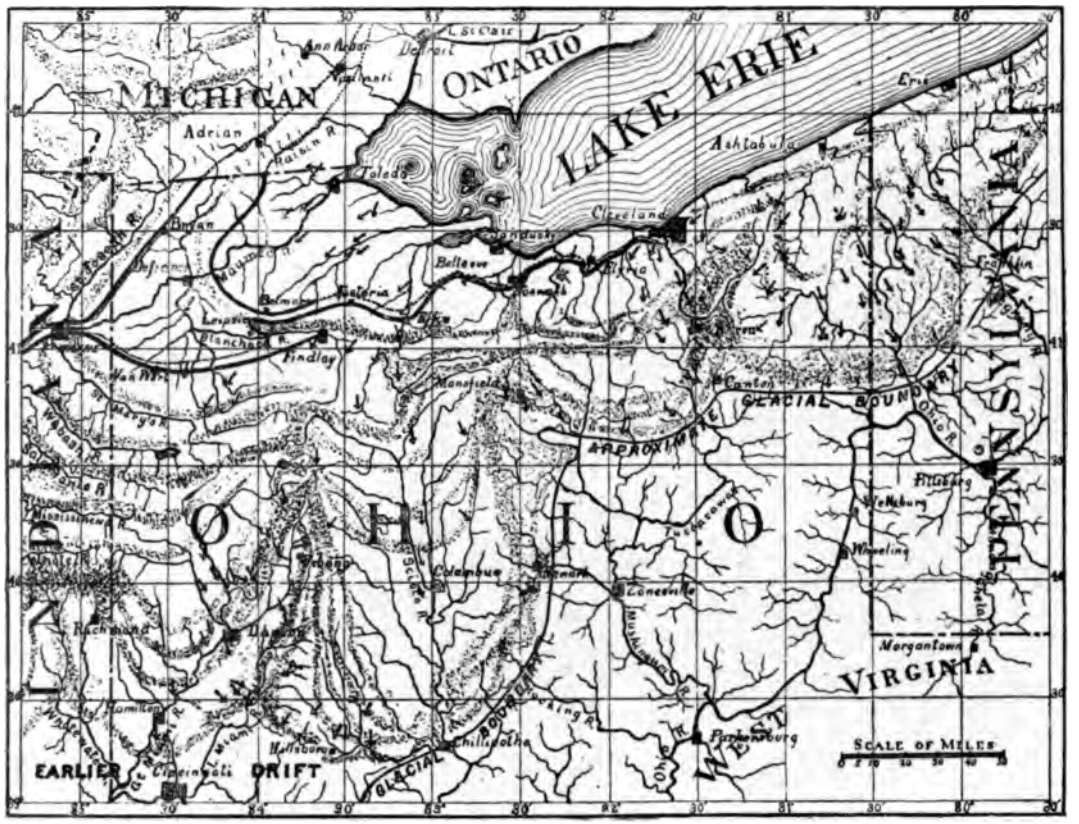
* Proc. Am. Ass. Adv. Sci. 1872, pp. 171-179. Geol. of Ohio, Vol. II., p. 56.

†Am. Journ. of Science, May 1871, p. 341. Geol. of Ohio, Vol. I. 1873. p. 540.



Map of the Western Erie Basin and adjacent territory. By Frank Leverett.

Explanation of Map.—The shaded portions represent moraines. Beach lines completely traced are represented by continuous lines, those incompletely traced by broken lines. Strias are indicated by arrows.

The altitude of the Van Wert beach throughout its course in Indiana and Ohio, has a variation of scarcely ten feet, the general altitude being very nearly 210 feet above Lake Erie. In Michigan it has been examined by Dr. J. W. Spencer, who reports a marked northward differential uplift between Ypsilanti and Berville, its altitude being 211 feet at Ypsilanti, and 244 feet at Berville.*

The Van Wert ridge, so far as I have examined it, consists in the main of a deposit of sandy gravel. It is not a strong beach, its usual height being three to five feet and its breadth but ten to twelve rods. Its pebbles are often but slightly worn, an indication that wave action was not strong. It is not improbable that throughout a larger portion of the year than at present the lake shore was fringed by ice. Fossils are extremely rare if not entirely absent from this beach, a feature which accords well with the view that the beach was formed during the low temperature of the glacial period, though it is merely negative evidence, since the absence or scarcity of fossils is not always due to the original absence of life, but often to the lack of conditions for preservation.

(b) *The Blanchard Moraine.*--The Blanchard is the latest moraine of the series in Ohio, that can be traced around the western end of Lake Erie. Westward from Findlay the moraine, though a less conspicuous feature than eastward from that city, was recognized and mapped by Mr. Gilbert more than twenty years ago.† It is, therefore, one of the earliest recognized moraines on this continent. From near the meridian of Findlay eastward it resembles the earlier moraines in presenting a broadly ridged and slightly undulatory tract of till, standing twenty to forty feet above the plain south of it, and having a breadth of one and one-half to three miles. Near the meridian referred to it assumes a very different appearance, that of a knob and basin topography of subdued type in which knolls of conical form rise abruptly five to ten feet and cover an acre or less each, and among which are sharp basins occupying usually but a small fraction of an acre each, though frequently several feet in depth. The crest of the moraine is no longer well defined though it continues to be a water shed-between tributaries of the Maumee, all the way to that stream near Defiance.

The structure presents as marked a change as the topography. Instead of a uniform deposit of till at the surface, there is a variety of formations remarkable for the abruptness of their alternations. In one knoll a fine sand may occur while its neighbors are composed of clay, or a portion of a knoll may be sand and the remainder clay, the whole being moulded together in a symmetrical knoll, like the gravel and till in ordinary kames. A few knolls contain gravel but as a rule pebbles are rare, and no surface bowlders or large pebbles were observed. The clays are very calcareous and abound in nodules in nearly every exposure.

* Am. Journ. Sci. March 1891.

† Am. Journ. Sci., May 1, 1871, pp. 339-342.

Such is the character of the moraine for a distance of ten or twelve miles. About three miles northwest of Leipsic, near the center of township 2 north, range 7 east, the Leipsic or second beach crosses the moraine, and from there northwestward the moraine has a comparatively smooth surface, the result of wave action subsequent to the retreat of the ice.

The portion of the moraine of especial interest is the knob and basin tract, above described. If my interpretation be correct this owes its peculiar topography and structure to the presence of lake water beneath the ice-margin. This portion of the moraine has an altitude but slightly below the level of the Van Wert Beach, consequently the water was shallow and incapable of buoying up the ice-sheet and producing icebergs. The result was what might be anticipated under such conditions of deposition, a variable structure produced by the motion of water under the edge of the melting ice-sheet, and an uneven surface moulded by the inequalities of its base and margin. It may be suggested that the moraine received its sandy deposits from a lake that covered it after the ice had retreated. It seems improbable, however, that such was the case, (1) because the sandy deposits are not in the form of a beach nor in any way connected with a well defined beach, but consist of sharp knolls similar to the clay knolls of the moraine; (2) because the sand in places graduates into clay of glacial origin showing contemporaneous deposition with it; (3) because the basins and depressions are so sharp and of such a form and arrangement as to forbid the idea that wave action was long exerted on them; (4) the portion of the moraine northwestward from where the Leipsic beach crosses, affords a clear illustration of the effect of an open lake on the moraine, its surface being smooth and its sand either a uniform coating or aggregated into forms clearly referable to wave or wind action. It is fortunate that the lake in its later stages fell short a few feet of reaching its earlier maximum stage, and thus left unmodified a portion of what appears to be a lake-deposited moraine. So far as I am aware no case of a moraine demonstrably formed in lake water has been reported from other parts of the glaciated district, but it is not improbable that other instances will be found when attention is directed more closely to the subject, if they have not already been observed by other students. It is quite probable that in portions of this moraine further north there will be found other places similar to that described.

Summing up the phenomena of this district it appears, (1) that the Van Wert ridge terminates near Findlay, Ohio, and that east from there the Blanchard moraine is its correlative, (2) that the Blanchard moraine from near the line of Putnam and Hancock counties northward was deposited in lake water. The beach as well as the morainic phenomena, therefore, support the hypothesis that the lake bounded by the Van Wert beach was of *glacial* age.

II. THE LEIPSIC OR SECOND BEACH AND ITS CORRELATIVE MORAINE.

(a) *The Leipsic or Second Beach.*—This beach was traced from the Blanchard river, near Ottawa, eastward to its eastern terminus near Cleveland. Its course is not known west from the meridian of Ottawa, but it is probably the correlative of Mr. Gilbert's "Second Beach" that passes through Bryan and Hicksville, Ohio, since it has about the same altitude as that beach, and since no other beach that could be a correlative has been found.

In the portion already traced the course of the beach is winding, following pretty closely a contour line 195 to 200 feet above the lake, though for a portion of its course, lying between the villages of Van Buren and Bellevue, it has an altitude about 210 feet above the lake.

From the Blanchard river, at a point about three miles above Ottawa, it passes northwestward along the outer face of the Blanchard moraine for a distance of 9 to 10 miles. Here it crosses the moraine and passes south of east along its inner face for a few miles. It then leaves the moraine to the south and takes a course north of east, through McComb and Van Buren, to Fostoria. From Fostoria it bears south of east through Bascom to the Sandusky river at Tiffin, then northeast to Bellevue, southeast to the Huron river, near Pontiac, northeast again nearly to Elyria, then south a few miles to Black river, after which it takes nearly a direct course toward its eastern terminus near Cleveland. The bays at Sandusky, Huron and Black rivers, were not formed by the cutting back of the shore of the lake, for a restoration of the original slope on which the shore was carved, shows that the lake nowhere cut back its shore a mile, and usually but a few rods. The general appearance of this beach is much like that of the Van Vert, though it is on the whole somewhat stronger, its wave cut benches standing often 6 to 8 feet, and occasionally 15 to 20 feet, above the inner border plain. Its gravels like those of the Van Wert beach contain many pebbles which are but slightly rounded, and there are many places where bowlders are imbedded in the beach deposits. The only fossils discovered are the horns of elk and deer which were obtained in a railway gravel pit three miles east of Ottawa, from undisturbed gravel at a depth of 7 to 9 feet from the surface. All the evidence collected favors the view that the shore throughout a large portion of the year was protected by ice from the action of the waves.

As previously stated the Leipsic beach has its terminus near Cleveland. The beach here connects with the western end of a moraine. Between Rockport and Linndale the beach swings from a course north of east, to a southerly course, and is there made up of a series of ridges of nearly uniform height, which are united at the curving portion of the ridge, but diverge into distinct ridges toward the southeast, so that their ends are spread out over a space of nearly one-half mile. The outer

ridge comes to Big Creek bluff in North Linndale. There is outside of these beach ridges a peculiar ridge, which appears to be a compromise between a beach and a moraine. At its western end, near the inner bend of a tributary of Big Creek, a mile or so west of North Linndale, it is composed of gravel, and resembles in every way the beaches just north of it, but upon tracing it eastward the gravel changes to till, giving it the appearance of a low glacial ridge. This low till ridge may be traced through North Linndale to the bluff of Big Creek, near the bend of that stream, and upon crossing the creek we find a much larger ridge of till, one worthy the name moraine. This larger ridge is separated from the eastern end of the beach proper by the narrow valley of Big Creek, one-fourth mile or less in width. I was unable to find beach gravel along the inner (north) slope of the morainic ridge, further east than the terminus of the beach ridge, but this inner border district is very flat, and its clays contain few pebbles compared with the clays of the moraine. These features apparently indicate that the lake water covered the tract north of the moraine, either while the ice overhung it or subsequently.

(b) *The Correlative Moraine of the Leipsic Beach.*—This moraine as indicated above, is traceable no further west than North Linndale. Both north and west from there the surface, aside from the low beaches, is a monotonous plain with scarcely any undulation. The disappearance of the moraine at the point where the beach appears, leaves little room for doubt that the ice-sheet here terminated in a lake, and that the beach is of glacial age. The portion of the moraine west of the Cuyahoga does not show evidence that it was deposited in lake water. On the contrary, its structure, so far as exposed, opposes such a theory of deposition, the mass of the ridge being ordinary till without capping of sand or other water deposits. The descent is rapid toward the Lake Erie basin from the junction of the beach and moraine; there was probably sufficient depth of water to cause the ice-sheet to break up into bergs at its margin instead of resting on the lake bottom and forming such a moraine as it did in the western Erie basin, northward from the junction of the Van Wert beach and Blanchard moraine.

Tracing the moraine eastward we find it passing just south of the village of Brighton, near which it is interrupted by the Cuyahoga valley. It reappears on the east side of the river in Newburg and is traceable from there eastward, through Randall and Warrensville to the Chagrin river below Chagrin Falls. West of the Cuyahoga it is a single gently undulating ridge, about 80 rods in width and 20 to 30 feet in height. East of the river it consists of many short ridges and conical swells 10 to 25 feet in height and has a width of one to two miles or more. In places there is a well defined crest, but as a rule the crest is wanting.

The range of altitude is considerable. West of the Cuyahoga the moraine stands about 800 feet A. T. East of the river it rises from 800 feet

at Newburg to 1,050 feet at Randall (only six miles distant), and ranges up and down 200 to 250 feet in eastern Cuyahoga and Geauga counties in crossing ridges and valleys, its highest points being about 1,250 feet A. T.

The thickness of drift as shown by its relief above border districts is only twenty to thirty feet, but spread out as it is over a width of one to two miles, it represents an accumulation at least 100 times that of the correlative beach. The moraine is composed principally of till, though in places it has gravelly knolls (kames). Pockets of gravel and sand occur in the till, and beds of assorted material are occasionally interstratified with it. In short, the moraine in its topography, range in altitude, bulk and constitution, is so different from the beach that the two formations cannot be confused, and yet there seems to be no question that the moraine of the eastern Erie basin has, in the western Erie basin, a beach for its correlative.

III. THE BELMORE BEACH AND ITS CORRELATIVE MORAINE.

Between the Leipsic beach and the present shore of Lake Erie, there are several beaches. One of these, the Belmore beach, terminates near Cleveland, the others continue eastward into southwestern New York, and do not concern us in the present discussion. From its eastern terminus westward to the meridian of Belmore and Leipsic, the Belmore beach lies only one to three miles and in places, as at Berlin Heights, only a few rods north of the Leipsic beach. Westward from this meridian the courses of the two beaches are quite divergent, the Leipsic bearing south of west, while the Belmore bears northwestward crossing the Maumee river near Defiance, from which stream it bears east of north into Michigan. The general altitude of the Belmore beach within the state of Ohio is 160 to 170 feet above Lake Erie. It lies, therefore, too low to open southwestward, as do the earlier beaches, through the Ft. Wayne outlet.

In size and general appearance this beach differs but little from the Leipsic, but is on the whole more sandy.

The ridge phase of the Belmore beach apparently exists no further east than the Cuyahoga river but it is thought that the lower of the two terraces in the eastern part of Cleveland was occupied by the lake at the time this beach was forming. The absence of a beach, in the eastern Erie basin, which could be considered a correlative of the Belmore beach, has been determined by Mr. Gilbert, we therefore are led to inquire whether a moraine occurs there as a correlative of the beach.

The innermost moraine formed on the southern borders of the Lake Erie basin, is distinctly traceable from the eastern end of the lake, westward to Euclid, Ohio, a village situated about ten miles east from the mouth of the Cuyahoga. The gap between the western end of the moraine and the eastern end of the ridge phase of the Belmore beach, is, therefore, about ten miles, but between the moraine and the Cleveland

terrace it is scarcely half that distance, and I am not certain but that the terrace may find occasional development along the face of the bold escarpment south of Lake Erie, as far east as the western terminus of the moraine. But should the gap between the moraine and the beach prove to be five or even ten miles, it would not follow that they cannot be correlated with each other, for the position of the boundary between the ice-sheet and the lake may have oscillated through a distance as great as this gap, during the course of the period in which the moraine and beach were forming. The failure or disappearance of the beach necessitates an explanation, and the only probable one yet found, is that the ice-sheet excluded the lake from the eastern portion of the basin, and the disappearance of this moraine near the eastern end of the beach, though it does not connect as closely with the beach as do earlier moraines with their correlative beaches, leaves no reasonable room for doubt that it is the correlative of the Belmore beach.

SUMMARY AND CONCLUSIONS.

From the data above presented it appears that Lake Erie in its earlier stages was but a small body of water, its size being conditional on the position of the retreating ice-sheet, and the height of the western rim of the basin it occupied. It at first occupied only a portion of the district between the outlet and the western end of the present lake, the remainder of the basin, including the whole of the area of the present lake, being occupied by the ice-sheet. Its south and north shores were then at the Van Wert ridge, while its eastern border was at the Blanchard moraine. At the time of the formation of the Leipsic and Belmore beaches the area of the lake was nearly as great as the present area of Lake Erie, though it occupied but little of the present bed of the lake.

From the phenomena attending the replacement of the three beaches in Ohio by moraines, we are led to suspect that the two later beaches which die away in southwestern New York are there connected with moraines, and that similar moraines will be found to connect with the beaches of Lake Ontario at points where they disappear on its eastern and northern borders.

Differential uplift was slight in the western Erie basin compared with what it was in the eastern Erie basin and the Ontario, and on the shores of Lake Huron and Georgian Bay. The data at hand indicate that it amounts to scarcely more than ten feet in the whole area of the portion of the Erie basin west of Cleveland, and has therefore played an insignificant part in causing the three stages of the lake herein described.

The bulk of the moraines is many times that of the beach deposits, though no longer time was involved in their deposition. The ice-sheet was, therefore, a much more efficient transporting agency than the lake waves.

The extreme scarcity of evidence of life in these waters is a feature quite accordant with the theory deduced from the relation of the beaches to the moraines, that the lake was of glacial age.

THE CUNEIFORM INSCRIPTIONS ON THE MONUMENTS OF THE ACHÆMENIDES*

TRANSLATED BY

HERBERT CUSHING TOLMAN, PH. D.

THE SEPULCHRAL INSCRIPTION OF CYRUS.

The oldest inscription of Persia is found on that structure generally believed to be the tomb of Cyrus. At Pasargadae, in the midst of the plain of Murghab, stands a building of white marble rising to the height of thirty-six feet from the ground. Its base is forty-seven feet long and forty-four feet broad. A figure in bas-relief carved on a pillar, perhaps the portrait of the king himself, strengthens the theory that this structure is the tomb of Cyrus. A narrow doorway leads into an inner chamber, where Arrian says, the body of Cyrus was placed. Under the relief is the cuneiform inscription, the translation of which follows:

I (am) Cyrus, the king, the Achaemenide.

For the sake of comparison I add the epitaph of Cyrus quoted by Strabo, (XV, 3.)

Ω ἄνθρωπε, ἐγὼ Κῦρος εἰμί ὁ Καμβύσου, ὁ τὴν αρχὴν Πέρσαις καταστησάμενος καὶ τῆς Ασίας βασιλεύσας. Μὴ οὖν φθονήσῃς μοι τοῦ μνήματος.

* For the original text of the inscriptions the reader is referred to the translator's Old Persian Grammar, published by Ginn & Co., Boston, Mass. (1892).

THE INSCRIPTION OF DARIUS HYSTASPES AT BEHISTAN.

The longest and most important of the Old Persian inscriptions is the great monument of Behistan. The name *Behistan* forms a dependent compound, the first member being BAGA (*God*) and the second STANA (place.) Behistan or "Place of God" was known to the Greeks who gave it the name *βαγίστανον ὄρος*. This immense rock rises abruptly to a height of 1,700 feet from the plain below. No place in all Persia could Darius have found more fitted for the purpose of holding an everlasting memorial of his reign. The bas-reliefs are uninjured and show a row of nine usurpers bound with a cord about their necks. In front of them stands the monarch who treads upon the prostrate body of a tenth victim. Behind Darius are two attendants, armed with the spear and bow. The figures of the conquerer and his warriors are skillfully executed, while the rebels are intentionally represented as diminutive in size. Above the picture is an effigy of Auramazda, the greatest deity of the Persians.

Over the heads of the king and his captives are placed legends commemorating the monarch's triumphs and showing the ancestry of Darius and the fraud of the usurpers. Below the reliefs in five parallel columns occurs the inscription of nearly one thousand lines, the translation of which I make at this point.

I.

1. I (am) Darius, the great king, the king of kings, the king in Persia, the king of countries, the son of Hystaspes, the grandson of Arshama, the Achaemenide.

2. Says Darius the king my father (is) Hystaspes, the father of Hystaspes (is) Arshama, the father of Arshama (is) Ariyaramna, the father of Ariyararamna (is Caispis*), the father of Caispis (is) Achaemenes.

3. Says Darius the king therefore we are called the Achaemenides: from long ago we have extended† from long ago our family have been kings.

4. Says Darius the king VIII.‡ of my family (there were) who were formerly kings: I am the ninth IX: individually we were (lit. are) kings.

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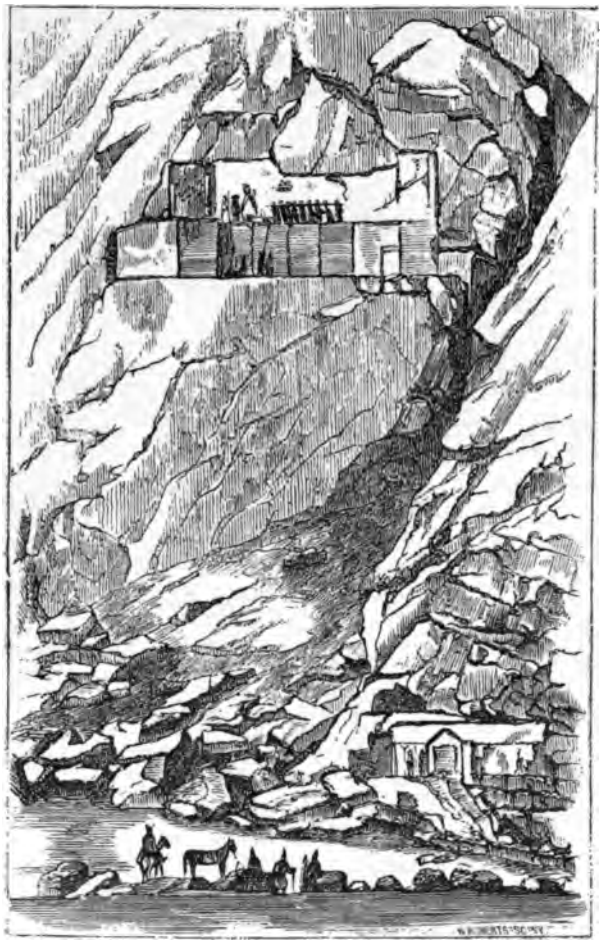
* Caispis is omitted by the carelessness of the stone-cutter. It is easily supplied from the inscription above the head of Darius which repeats these introductory sections; vide infra.

† The Persian word AMATA I connect with the Sanskrit root MA *to measure* (Cf. Zend MA and Latin ME-TO). The A is doubtless a prefix corresponding to the Sanskrit A (hither). AMATA would mean *measured hither* or *to the present time*, i. e. reaching to the present. It is possible to emphasize the idea of the root MA (measure): hence the word might signify *measured, tested, tried*.

‡ The numerals are represented by horizontal wedges for the units and oblique for the tens.



The Behistan Mountain.

5. Says Darius the king by the grace of Auramazda I am king: Amamazda gave me the kingdom.

6. Says Darius the king these are the countries which came to me: by the grace of Auramazda I became king of them, Persia, Susiana, Babylon, Assyria, Arabia, Egypt, which are by the sea, Sparda, Ionia, Media, Armenia, Cappadocia, Parthia, Drangiana, Area, Chorasmia, Bactriana, Sogdiana, Gandara, Saka, Thatagus, Haravatis, Maka, in all (there are) XXIII countries.

7. Says Darius the king these (are) the countries which came to me: by the grace of Auramazda they became subject to me: they bore tribute to me: what was commanded to them by me this was done night and (lit. or) day.

8. Says Darius the king within these countries what man was a friend* him well supported I supported: who was an enemy him well punished I punished; by the grace of Auramazda these countries followed my law: as it was commanded by me to them, so it was done.

9. Says Darius the king Auramazda gave me the kingdom; Auramazda bore me aid until this kingdom was established: by the grace of Auramazda I hold this kingdom.

10. Says Darius the king this (is) what (was) done by me after that I became king; Cambyses by name, the son of Cyrus (was) of our family: he before was king here: of this Cambyses there was a brother Bardiya (i. e. Smerdis) by name possessing a common mother and the same father with Cambyses; afterwards Cambyses slew that Bardiya: when Cambyses slew Bardiya, there was not knowledge† (on the part) of the state that Bardiya was slain: afterwards Cambyses went to Egypt: when Cambyses went to Egypt, after that the state became hostile, after that there was deceit to a great extent in the provinces, both Persia and Media and other provinces.

11. Says Darius the king afterwards there was one man, a Magian, Gaumata by name; he rose up from Paishiyauvada; there (is) a mountain Arakadris by name; from there on the 14th day‡ of the month Viyakhna then it was when he rose up: he then deceived the state; I am Bardiya the son of Cyrus brother of Cambyses: afterwards the whole state became estranged from Cambyses (and) went over to him, both Persia and Media and the other provinces: he siezed the kingdom; on the 9th day of the month Garmapada then it was he thus seized the kingdom; afterward Cambyses died by a self-imposed death.

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* The Persion word is of doubtful interpretation. It looks like the NOMEN AGENTIS of GAM *to go, a goer hither* or a *comer*. The translation *friend* is a conventional one.

† AZDA, a doubtful word. I connect it with the root DA *to know* which occurs in the compound AURAMAZDA.

‡ Lit. with fourteen days; a use of the instrumental which denotes the association of time with an event. This idiom is employed in all like temporal expressions.

The word UVAMARSHIYUSH I divide into UVA *self* (Cf. Skt. SVA. Lat. SE) and MARSHIYUSH

12. Says Darius the king this kingdom which Gaumata the Magian took from Cambyses, this kingdom from long ago was (the possesion) of our family: afterwards Gaumata the Magian took from Cambyses both Persia and Media and the other provinces; he acted in accordance with? his own pleasure? he became king.

13. Says Darius the king there was not a man neither a Persian nor Median nor anyone of our family who could make Gaumata the Magian deprived of the kingdom; the state feared him vehemently (or because of his violence); he would smite the state utterly which knew the former Bardiya; for this reason he would smite the state that it might not know me* that I am not Bardiya the son of Cyrus; any one did not dare to say anything against Gaumata the Magian until I came; afterwards I asked Auramazda for help; Auramazda bore me aid; an the 10th day of the month Bagayadis then it was I thus with (my) faithful? men slew that Gaumata the Magian and what men were his foremost allies; there (is) a stronghold Sikayauvatis by name;† there is a province in Media Visaya by name; here I smote him; I took the kingdom from him; by the grace of Auramazda I became king: Auramazada gave me the kingdom.

14. Says Darius the king—the kingdom which was taken away from our family, this I put in (its) place; I established it on (its) foundation; as (it was) formerly so I made it; the sanctuaries? which Gaumata the Magian destroyed I restored. The commerce? of the state and the cattle and the dwelling places and in accordance with‡ the clans which Gaumata the Magian took from them (I restored); I established the state on (its) foundation both Persia and Media and the other provinces; as (it was) formerly so I brought back what (had been) taken away; by the grace of Auramazda this I did; I labored that our clan I might establish in (its) place; as (it was) formerly, so (I made it); I labored by the grace of Auramazda that Gaumata the Magian might not take away our race.

15. Says Darius the king this (is) what I did, after that I became king.

16. Says Darius the king when I slew Gaumata the Magian afterwards there (was) one man Atrina by name the son of Upadara(n)ma; he rose up in Uvaja (i. e. Susiana); thus he said to the state; I am king in Uvaja; afterwards the people of Uvaja became rebellious (and) went over to that Atrina; he became king in Uvaja; also there (was) one man a Babylonian Naditabira by name the son of Ain.....; he rose up in Babylon; thus he deceived the state; I am Nabukudracara the son of Nabunita; afterwards the whole of the Babylonian state went over to

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die (Cf. Skt. MAR Lat. MORIOR). The meaning also corresponds to the statement in Herodotus III 64-65. that Cambyses died from a wound inflicted by his sword as he was leaping from his horse.

* Note the direct form of expression.

† NAMA is not the accusative of specification but is attacted into the case and even the gender of the subject. Lit. there is a stronghold (its) name (is) Sikayauvatis.

‡ The transition from the accusative to the instrumental is hard to explain.

that Naditabira; Babylon became rebellious; the kingdom in Babylon he seized.

17. Says Darius the king afterwards I sent forth (my army) to Uvaja; this Atrina was led to me bound; I slew him.

18. Says Darius the king afterwards I went to Babylon against that Naditabira who called himself Nabukudracara; the army of Naditabira held the Tigris; there he halted and was on shipboard; afterwards I destroyed the army ..... one (army) I made submissive, of the other ..... I led; Auramazda bore me aid; by the grace of Auramazda we crossed the Tigris; here the army of Naditabira I slew utterly; on the 27th day of the month Atriyadiya then it was we thus engaged in battle.

19. Says Darius the king afterwards I went to Babylon; when to Babylon .....; there (is) a town Zazana by name along the Euphrates; there this Naditabira who called himself Nabukudracara went with his army against me to engage in battle; afterwards we engaged in battle; Auramazda bore me aid; by the grace of Auramazda the army of Naditabira I slew utterly .... the water bore it away; on the 2nd day of the month Anamaka then it was we thus engaged in battle.

II.

1. Says Darius the king afterwards Naditabira with (his) faithful? horsemen went to Babylon; afterwards I went to Babylon; by the grace of Auramazda I both seized Babylon and seized that Naditabira; afterwards I slew that Naditabira at Babylon.

2. Says Darius the king while I was in Babylon these (are) the provinces which became estranged from me, Persia, Uvaja, Media, Assyria, Armenia, Parthia, Magus, Thatagus, Saka.

3. Says Darius the king there (was) one man Martiya by name, the son of Cicikhris — there (is) a town in Persia Kuganaka by name — here he halted; he rose up in Uvaja; thus he said to the state; I am Imanis king in Uvaja.

4. Says Darius the king then I was near by Uvaja; afterwards from me ..... the people of Uvaja seized that Martiya who was chief of them and slew him.

5. Says Darius the king one man Fravartis by name, a Mede, he rose up in Media; thus he said to the state; I am Khshathrita of the family of Uvakhshatara; afterwards the Median state which was in clans became estranged from me (and) went over to that Fravartis; he became king in Media.

6. Says Darius the king the Persian and Median army, which was by him, it was faithful? (lit. a faithful (?) thing); afterwards I sent forth an

army; Vidarna* by name, a Persian, my subject him I made chief of them; thus I said to them: go smite that Median army which does not call itself mine; afterwards this Vidarna with the army went away; when he came to Media ..... there (is) a town in Media ..... by name — here he engaged in battle with the Medes; he who was the chief among the Medes did not then hold (the army) faithful ?; Auramazda bore me aid; by the grace of Auramazda the army of Vidarna smote that rebellious army utterly: on the 6th day of the month Anamaka then it was the battle (was) thus fought by them; afterwards my army — there (is) a region Ka(m)pada by name — there awaited me until I went to Media.

7. Says Darius the king afterwards Dadarsis by name, an Armenian, my subject, him I sent forth to Armenia; thus I said to him: go, the rebellious army which does not call itself mine smite it; afterwards Dadarsis went away; when he came to Armenia, afterwards the rebellious ones having come together went against Dadarsis to engage in battle ..... a village ..... by name in Armenia; here they engaged in battle; Auramazda bore me aid; by the grace of Auramazda my army smote that rebellious army utterly; on the 6th day of the month Thuravahara then it was thus the battle (was) fought by them.

8. Says Darius the king a second time the rebellious ones having come together went against Dadarsis to engage in battle; there (is) a stronghold, Tigra by name, in Armenia - - here they engaged in battle: Auramazda bore me aid; by the grace of Auramazda, my army smote that rebellious army utterly; on the 18th day of the month, Thuravahara then it was the battle (was) thus fought by them.

9. Says Darius the king a third time the rebellious ones having come together went against Dadarsis to engage in battle; there (is) a stronghold, U.....ama by name, in Armenia - - here they engaged in battle: Auramazda bore me aid; by the grace of Auramazda my army smote that rebellious army utterly; on the 9th day of the month, Thaigarcis then it was thus the battle (was) fought by them; afterwards Dadarsis awaited me until I came to Media.

10. Says Darius the king afterwards Vaumisa by name, a Persian, my subject, him I sent forth to Armenia ; thus I said to him: go, the rebellious army which does not call itself mine, smite it; afterwards Vaumisa went away; when he came to Armenia afterwards, the rebellious ones having come together went against Vaumisa to engage in battle; there (is) a region, ... by name, in Assyria — here they engaged in battle; Auramazda bore me aid; by the grace of Auramazda my army smote

* A nominative in apposition with an accusative. This weak syntax is common to the Old Iranian languages. Artificially the construction can be explained by supplying ASTI *is* and repeating the idea in the form of a pronoun. The boldest case is in III. 2. FRAISHAYAM DADARSHISH *I sent forth Dadarsis*, the nominative being used apparently as an object. For a fuller discussion of the subject the reader is referred to my Old Persian Grammar 61, A, notes, A 2.

that rebellious army utterly; on the 15th day of the month Anamaka, then it was thus the battle (was) fought by them.

11. Says Darius the king a second time the rebellious ones having come together went against Vaumisa to engage in battle; there (is) a region Autiyara by name in Armenia—here they engaged in battle; Auramazda bore me aid; by the grace of Auramazda my army smote that rebellious army utterly; ..... of the month Thuravahara ..... thus the battle (was) fought by them; afterwards Vaumisa awaited me in Armenia until I came to Media.

12. Says Darius the king afterwards I went from Babylon; I went away to Media; when I went to Media—there (is) a town Kudurus by name in Media—here this Fravartis (i. e., Phaortes) who called himself king in Media went with (his) army against me to engage in battle; afterwards we engaged in battle; Auramazda bore me aid; by the grace of Auramazda I smote the army of Fravartis utterly; on the 26th day of the month Adukanis then it was we engaged in battle.

13. Says Darius the king afterwards this Fravartis with faithful ? horsemen—in that place (was) a region Raga by name in Media—here went; afterwards I sent forth my army against them; Fravatis was seized (and) led to me; I cut off (his) nose and ears and tongue, and to him ..... I led; he was held bound at my court; the whole state saw him; afterwards I put (him) on a cross at Ecbatana, and what men were his foremost allies, these I threw within a prison at Ecbatana.

14. Says Darius the king one man, Citra(n)takhma by name, a Sagartian, he became rebellious to me; thus he said to the state; I am king in Sagartia, of the family of Uvakhshatara; afterwards I sent forth the Persian and Median army; Takhmaspada by name, a Mede, my subject, him I made chief of them; thus I said to them; go, the rebellious army, which does not call itself mine, smite it; afterwards Takhmaspada went away with the army (and) engaged in battle with Citra(n)takhma; Auramazda bore me aid; by the grace of Auramazda my army smote that rebellious army utterly and seized Citra(n)takhma (and) brought (him) to me; afterwards I cut off his nose and ears, and to him..... I led; he was held bound at my court; the whole state saw him; afterwards I put him on a cross in Arabia.

15. Says Darius the king this (is) what (was) done by me in Media.

16. Says Darius the king Parthia and Hyrcania .....of Fravartis..... called himself; Hystaspes my father..... army.....afterwards Hystaspes....allies.....town .... by name.....they engaged in battle.....thus the battle (was) fought by them.

III.

1. Says Darius the king afterwards I sent forth the Persian army to Hystaspes from Raga; when this army came to Hystaspes, afterwards Hystaspes with that army went away—there (is) a town Patigrabana by name in Parthia—here he engaged in battle with the rebellious ones; Auramazada bore me aid; by the grace of Auramazda Hystaspes smote that rebellious army utterly; on the first day of the month Garmapada then it was that thus the battle (was) fought by them.

2. Says Darius the king afterwards it became my province: this (is) what (was) done by me in Parthia.

3. Says Darius the king there (is) a region Margus by name; it became rebellious to me; one man Frada, a Margianian, him they made chief; afterwards I sent forth Dadarsis by name, a Persian, my subject, satrap* in Bactria against him; thus I said to him: go, smite that army which does not call itself mine; afterwards Dadarsis with the army went away (and) engaged in battle with the Margianians; Auramazda bore me aid; by the grace of Auramazda my army smote that rebellious army utterly; on the 23rd day of the month Atriyadiya then it was thus the battle (was) fought by them.

4. Says Darius the king afterwards it became my province; this (is) what (was) done by me in Bactria.

5. Says Darius the king one man Vahyazdata by name—there (is) a town Tarava by name; there (is) a region Yutiya by name in Persia—here halted; he a second time (i. e. after Gaumata) rose up in Persia; thus he said to the state: I am Bardiya the son of Cyrus; afterwards the Persian army which (was) in clans departed from duty; it became estranged from me (and) went over to that Vahyazdata; he became king in Persia.

6. Says Darius the king afterwards I sent forth the Persian and Median army which was by me; Artavardiya by name, a Persian, my subject, him I made chief of them; the other Persian army went with (lit. after) me to Media; afterwards Artavardiya with the army went to Persia; when he came to Persia—there (is) a town Rakha by name in Persia—here this Vahyazdata who called himself Bardiya went with (his) army against Artavardiya to engage in battle; afterwards they engaged in battle; Auramazda bore me aid; by the grace of Auramazda my army smote that army of Vahyazdata utterly; on the 12th day of the month Thuravahara then it was thus the battle (was) fought by them.

7. Says Darius the king afterwards this Vahyazdata with faithful? horsemen then went to Paishiyauvada; from thence he went with an army

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* The Persian word KHSHATRAPAVAN (satrap) is lit. *protecting the kingdom;* KHSHATRA *kingdom* (Cf. ARTAKHSHATRA, Artaxerxes) and PA *protect* (Cf. Skt. and Zend PA, Lat. PA-VI, PA-S, FODA and the root in the Lat. PATER and its cognates.

again against Artavardiya to engage in battle; there (is) a mountain Paraga by name—here they engaged in battle; Auramazda gave me aid; by the grace of Auramazda my army smote that army of Vahyazdata utterly; on the 6th day of the month Garmapada then it was thus the battle (was) fought by them and they seized that Vahyazdata and what men were his foremost allies they seized.

8. Says Darius the king afterwards—there (is) a town in Persia Uvadaidaya by name*—here, that Vahyazdata and what men were his foremost allies, them I put on a cross.

9. Says Darius the king this Vahyazdata who called himself Bardiya he sent forth an army to Harauvatis—there (was) Vivana by name, a Persian, my subject, satrap in Harauvatis—against him (he sent an army) and one man he made chief of them; thus he said to them: go, smite that Vivana and that army which calls itself of Darius the king afterwards this army, which Vahyazdata sent forth, went against Vivana, to engage in battle; there (is) a stronghold Kapishakanis by name—here they engaged in battle; Auramazda bore me aid; by the grace of Auramazda my army smote that rebellious army utterly; on the 13th day of the month Anamaka then it was thus the battle (was) fought by them.

10. Says Darius the king again the rebellious ones having come together went against Vivana to engage in battle; there (is) a region Ga(n)dutava by name—here they engaged in battle; Auramazda bore me aid; by the grace of Auramazda my army smote that rebellious army utterly; on the 8th day of the month Viyakhna then it was thus the battle (was) fought by them.

11. Says Darius the king afterwards this man, who was chief of that army which Vahyazdata sent against Vivana, this chief with faithful? horseman went away—there (is) a stronghold Arshada by name in Harauvatis—he went beyond thence; afterwards Vivana, with an army on foot went (against) them; here he seized him and what men were his foremost allies he slew.

12. Says Darius the king afterwards the province became mine; this is what was done by me at Harauvatis.

13. Says Darius the king when I was in Persia and Media a second time the Babylonians became estranged from me; one man, Arakha by name, an Armenian son of Han(?)dita,† he rose up in Babylon; there (is)

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* The reader has noticed the constant use of paratax. Instead of bringing the words of the sentence into syntax independent constructions are employed. In no other language is this loose arrangement (which we must feel was original to speech) shown to better advantage than in the old Persian inscriptions.

† The N in Handita as well as the N in Dubana conjecture has supplied. The combination of wedges in the cuneiform text resembles no other characters on the stone and perhaps is the sign for L which otherwise would be wanting in the Old Persian alphabet. I however feel that it is simply a careless writing of the nasal.

a region, Duban(?)a by name—from there he rose up; thus he lied; I am Nabukudracara, the son of Nabunita; afterwards the Babylonian state became estranged from me (and) went over to that Arakha; he seized Babylon; he became king in Babylon.

14. Says Darius the king afterwards I sent forth my army to Babylon; Vi(n)dafra by name, a Mede, my subject, him I made chief; thus I said to them; go, smite that army in Babylon which does not call itself mine; afterwards Vi(n)dafra with an army went to Babylon; Auramazda bore me aid; by the grace of Auramazda, Vi(n)dafra seized Babylon..... on the 2d day of the mouth.....then it was thus.....
.....
.....
.....

IV.

1. Says Darius the king this (is) what was done by me in Babylon.

2. Says Darius the king this (is) what I did; by the grace of Auramazda it was (done) wholly in (my) way;* after that the kings became rebellious I engaged in XIX battles; by the grace of Auramazda I smote them and I seized IX kings; there was one, Gaumata by name, a Magian; he lied; thus he said; I am Bardiya the son of Cyrus; he made Persia rebellious; there (was) one, Atrina by name, in Uvaja; he lied; thus he said; I am king in Uvaja; he made Uvaja rebellious to me; there (was) one, Naditabira by name, a Babylonian; he lied; thus he said; I am Nabukudracara the son of Nabunita; he made Babylon rebellious; there (was) one, Martiya by name, a Persian; he lied; thus he said; I am Imanis king in Uvaja; he made Uvaja rebellious; there (was) one Fravartis by name, a Mede; he lied; thus he said; I am Khshathrita of the family of Uvakhshatara; he made Media rebellious; there (was) one, Citra(n)takhma by name, in Sagartia; he lied; thus he said; I am king in Sagartia, of the family of Uvakhshatara; he made Sagartia rebellious; there (was) one, Frada by name, a Margianian; he lied; thus he said; I am king in Margus; he made Margus rebellious; there (was) one, Vahyazdata by name, a Persian; he lied; thus he said; I am Bardiya the son of Cyrus; he made Persia rebellious; there (was) one, Arakha by name, an Armenian; he lied; thus he said; I am Nabukudracara the son of Nabunita; he made Babylon rebellious.

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* HAMAHYAYA THARDA is of doubtful interpretation. Rawl. suggested "the performance of the whole"; Oppert "dans toute ma vie; dans toute l'année, toujours"; Spiegel "in aller Weiser" Many idle attempts have been made to connect THARDA with the Sanskrit ÇARAD, *autumn* used in the Veda metaphorically for *year*, but they are unsatisfactory. I feel that we have nothing which can give us light on this phrase.

3. Says Darius the king these IX kings I seized within these battles.

4. Says Darius the king these (are) the provinces which became rebellious; a lie made them *....that these deceived the state; afterwards Auramazda made them in my hand; as desire (moved) me, thus.....

5. Says Darius the king O thou who wilt be king in the future, protect thyself strongly from deceit; whatever man will be a deceiver, him punish well (lit. him well punished punish, Cf.. I. 8), if thus thou shalt think "may my country be firm."

6. Says Darius the king this (is) what I did; by the grace of Auramazda I did (it) wholly in (my) way;† O though who shalt examine this inscription in the future, let it convince thee (as to) what (was) done by me; do not deceived thyself.

7. Says Darius the king Auramazda (is) a witness? that this (is) true (and) not false (which) I did wholly in my own way.‡

8. Says Darius the king by the grace of Auramazda..... (what) else (was) done by me to a great extent, that (is) not inscribed on this inscription; for this reason it (is) not inscribed lest whoever will examine this inscription in the future ..... it may not convince him (as to) what (was) done by me (and) he may think (it) false.§

9. Says Darius the king who were the former kings, by these nothing (was) done to a great extent as (was) performed ¦ wholly by me though the grace of Auramazda.

10. Says Darius the king.....let it convince thee (as to) what (was) done by me; thus.....for this reason do not hide (this monument); if thou shalt not hide this monument (but) tell (it) to the state, may Auramazda be a friend to thee and may there be to thee a family abundantly and live thou long.

11. Says Darius the king if thou shalt hide this monument (and) not tell (it) to the state, may Auramazda be a smiter to thee and may there not be to thee a family.

12. Says Darius the king this (is) what I did wholly in (my) way;¶ by the grace of Auramazda I did (it); Auramazda bore me aid and the other gods which are.

13. Says Darius the king for this reason Auramazda bore me aid and the other gods which are, because I was not an enemy, I was not a deceiver, I was not a despot... .....family above law, above

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* Perhaps we can supply with Spiegel HAMITRIYA *a lie made them rebellious.*

† Cf. IV. 2.

‡ Cf. IV. 2.

§ Although much has become obliterated yet we have enough to enable us to gain the sense of the passage. The idea is: should I write the memorial of all my achievements, they would be so many that men would lose faith in the testimony of this stone.

¦ Cf. IV. 2. but here THARDA fails to appear.

¶ Cf. IV. 2.

me.....I did.....that whoever for me helped those belonging to my race, him well supported I supported; whenever .....him well punished I punished.

14. Says Darius the king O thou who art king in the future, whatever man shall be a deceiver.....shall be.....(be) not a friend to these; punish these with severe punishment.

15. Says Darius the king O thou who shalt see this inscription in the future which I inscribed or these pictures, thou shalt not destroy (them) as long as thou shalt live; thus guard them.

16. Says Darius the king if thou shalt see this inscription or these pictures (and) shalt not destroy them and shalt guard them for me as long as (thy) family shall be, may Auramazda be a friend to thee and may there be to thee a family abundantly and live thou long and whatever thou shalt do, this for thee (let) Auramazda..... let him grant thy prayers.

17. Says Darius the king if thou shalt see this inscription or these pictures (and) shalt destroy them and shalt not guard them for me as long as (thy) family shall be, may Auramazda be a smiter to thee and may there not be to thee a family and whatever thou shalt do this let Auramazda destroy for thee.

18. Says Darius the king these (are) the men who were there then when I slew Gaumata the Magian who called himself Bardiya; then these men cooperated as my allies; Vi(n)dafrana by name, the son of Vayaspara, a Persian; Utana by name, the son of Thukhra, a Persian; Gaubaruva by name, the son of Marduniya, a Persian; Vidarna by name, the son of Bagabigna, a Persian; Bagabukhsha by name, the son of Daduhya, a Persian; Ardumanis by name, the son of Vahauka, a Persian.

19. Says Darius the king O thou who art king in the future, what ..... what Darius .... I did.

V.

1. Says Darius the king this (is) what I did..... ..... way .... king ..... province; this became estranged from me; one man ..imina by name; the (people) of Uvaja made him chief; afterwards I sent forth (my) army to Uvaja; one man Gaubaruva by name, a Persian, my subject, him I made chief of them; afterwards this Gaubaruva with an army went to Uvaja; he engaged in

battle with the rebellious ones; afterwards .....
..... and to him .....
..... he seized and led to me ..... province .....
..... thus it .....
.....

2. Says Darius the king .....
.....
..... Auramazda ..... by the grace of Auramazda ..... I did.

3. Says Darius the king whoever in the future .....
.....
.....

4. Says Darius the king ..... I went against Saka .....
..... Tigris ..... to the sea .....
..... I seized the enemy ..... to .....
..... Saku(n)ka by name, him I seized .....
..... there another as chief .....
..... afterwards .....
.....

5. Says Darius the king ..... not Auramazda ..... if by the grace of Auramazda ..... I did.

6. Says Darius the king ..... worship? Aurmazda: .....
.....
.....
.....

Kossowicz remarks: "Notatu dignum omnium, quantum scio, imperatorum, qui armorum vi atque gloria celebres extiterant, nisi duo, Darium Hystaspi nempe et Napoleonem I — mum, commilitonum nomina, victorias suas recensendo, in publicis monumentis memoriae tradidisse."

THE SMALLER INSCRIPTIONS OF BEHISTAN.

A.

*Over the picture of Darius.**

I (am) Darius, the great king, king of kings, king of Persia, king of tl countries, the son of Hystaspes, the grandson of Arshama, the Acha menide. Says Darius the king my father (is) Hystaspes, the father Hystaspes (is) Arshama, the father of Arshama (is) Ariyaramna, tl father of Ariyaramna (is) Caispis, the father of Caispis (is) Achaemene Says Darius the king therefore we are called Achaemenides; from lor ago we have extended; from long ago our family have been kings. Sa; Darius the king VIII of my family (there were) who were formerly king I am the ninth IX; individually we are kings.

B.

Under the prostrate form.

This Gaumata the Magian lied; thus he said; I am Bardiya, the son Cyrus; I am king.

C.

Over the first standing figure.

This Atrina lied; thus he said; I am king in Uvaja.

D.

Over the second standing figure.

This Naditabira lied; thus he said; I am Nabuk (u) dracara, the son Nabunita; I am king in Babylon.

E.

Upon the garment of the third standing figure.

This Fravartis lied; thus he said; I am Khshathrita of the family Uvakhshatara; I am king in Media.

F.

Over the fourth standing figure.

This Martiya lied; thus he said; I am Imanis, king in Uvaja.

* Cf. I, 1-4.

G.

Over the fifth standing figure.

This Citra(n)takhma lied; thus he said; I am king in Sagartia, of the family of Uvakhshatara.

H.

Over the sixth standing figure.

This Vahyazdata lied; thus he said; I am Bardiya, the son of Cyrus; I am king.

I.

Over the seventh standing figure.

This Arakha lied; thus he said; I am Nabuk (u) dracara, the son of Nabunita; I am king in Babylon.

J.

Over the eighth standing figure.

This Frada lied; thus he said; I am king in Margus.

K.

*Over the ninth standing figure.**

This (is) Saku(n)ka, the Sakian.

* Herodotus mentions the high cap which was peculiar to the garb of the Sakians. It is interesting to note that the figure is represent on the stone wearing this national head-dress. Cf. plate, opp. page 242.

THE INSCRIPTION OF ALVEND.

This inscription is engraven upon two niches on a large block of stone near the base of Mt. Alvend. Not only is the monumental fame of Darius perpetuated by the Behistan mountain, but in different parts of the Persian empire this monarch caused to be inscribed historic records of his reign. At Persepolis the palaces declare the name of their founder and his prayers for the protection of heaven. To Darius beyond all others we are indebted for what we have of the Paleography of Persia. After translating the inscription indicated above I shall take up the remaining ones of this king at Persepolis, Suez, etc.

A great god (is) Auramazda who created this earth, who created yonder heaven,* who created man, who created the spirit? of man, who made Darius king, one king of many, one lord of many. I (am) Darius the great king, king of kings, king of the countries possessing many kinds of people, king of this great earth far and wide, the son of Hystaspes, the Achaemenide.

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* ASMAN (*heaven*) is literally *a stone* as we know from its cognate in Sanskrit. Probably the Persians regarded the sky as a solid dome; cf. the Hebrew word RAQI (A) (Gen. I. 8), and our *firmament* (firmamentum).

THE INSCRIPTIONS OF SUEZ.

A crowned head is carved upon the stone together with the legend:

A.

Darius the great king, king of kings, king of the countries, the son of Hystaspes, the Achaemenide.

Above are a dozen lines of Persian cuneiform text the translation of which follows.

B.

A great god (is) Auramazda, who created yonder heaven, who created this earth, who created man, who created the spirit ? of man, who made Darius king, who gave the kingdom to Darius; what great .... I (am) Darius the great king, king of kings, king of the countries possessing many people, king of this great earth far and wide, son of Hystaspes, the Achaemenide. Says Darius the king I am a Persian; with (the help of) Persia I seized Egypt; I commanded to dig this canal * from the Nile by name a river which flows in Egypt to the sea, which goes from Persia; afterwards this canal was dug there as I commanded ....

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* Cf. Herodotus IV. 39. *λήγει δὲ αὕτη (ἡ Ἀραβίη), ὀυ λήγουσα εἰ μη νόμῳ, ἐς τον κολπον τὸν Ἀραβιον, ἐς τον Δαρεῖος ἐκ τοῦ Νείλου διώρυχα ἐσήγαγε.*

THE INSCRIPTION OF LONDON.

The following short inscription can be seen in the British Museum on a cylinder which furnishes a fine specimen of gem engraving. A warrior in his charriot is represented as attacking at full speed a lion,* the symbol of power. This warrier from his crown we can interpret as King Darius. He holds his bow ready for action, while the charioteer urges on the steeds. This cylinder was carried to England from Egypt.

I (am) Darius the king.

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* On the Persian sculptures, the lion and bull occur often, as emblems of strength. Metaphors of this kind are frequent in all oriental literature. In making a list of the epithets of the god Indra in the Veda, I was struck with the repeated comparisons of this sort. However, the Vedic poets drew from the stall as the most fertile source of metaphors, and it was the later Sanskrit which used the beasts of the forest more extensively for that purpose. (e. g. the tiger of men, etc.) In Biblical literature the reader is referred to Ezekiel i. 10. "As for the likeness of their faces, they four had the faces of a man, and the face of a lion on the right side." Daniel vii. 4. "The first was like a lion and had eagles wings." The familiar national emblems of later date, the Roman eagle, the British lion, etc., all had their origin in this early conception.

THE INSCRIPTIONS OF DARIUS AT PERSEPOLIS.

The inscriptions of Persepolis show that same spirit of patriotism which characterizes the record on Mt. Behistan. The superiority of Persia over the provinces of the empire is set forth by the monarch with the purpose of elevating the feelings of his countrymen and of keeping alive ever in their hearts the love of country. The palace of Darius shows the ruins of several apartments with external chambers which were evidently guard-rooms. The roof of a large room, fifty feet square, was supported by pillars, the bases of which remain to-day. This edifice is one of those ruins which represent the combined work of several successive Achaemenian kings. All the structures stand upon the same platform around which are great walls of hewn stone. Two inscriptions are found above the wall and one on two pillars, which read as follows:

A.

Above the wall surrounding the palace.

The great Auramazda, who (is) the greatest of the gods, he made Darius king; he gave to him the kingdom; by the grace of Auramazda Darius (is) king. Says Darius the king this (is) the country Persia which Auramazda gave me, which, beautiful, possessing good horses, possessing good men, by the grace of Auramazda and (by the achievements) of me Darius the king, does not fear an enemy. Says Darius the king let Auramazda bear me aid with (his) fellow gods and let Auramazda protect this country from an army, from misfortune, from deceit; may not an enemy.... come unto this country, nor an army, nor misfortune nor deceit; this I pray of Auramazda....with (his) fellow gods; this let Auramazda give me with (his) fellow gods.

B.

Another inscription above the wall.

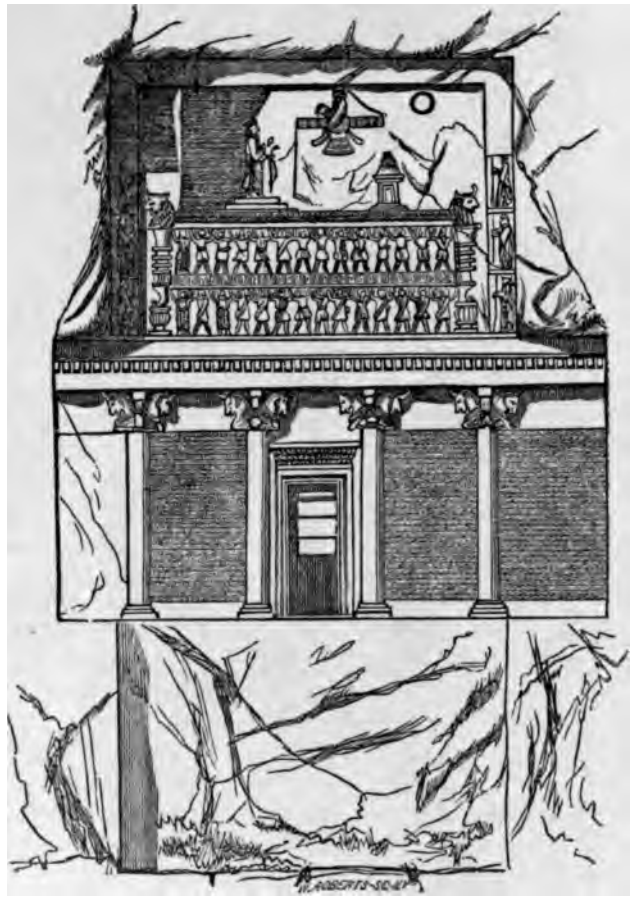
I (am) Darius the great king, king of kings, king of many countries, the son of Hystaspes, the Achaemenide. Says Darius the king by the grace of Auramazda these (are) the provinces which I subdued with (the help of) that Persian army, (and) which feared me (and) brought to me tribute; Uvaja, Media, Babylon, Arabia, Assyria, Egypt, Armenia, Cap-

padocia, Sparda, Ionia, which (are) of the dry (land) (and) which (are) of the sea, and the provinces which (are) in the east, Sagartia, Parthia, Zara(n)ka, Haraiva, Bactria, Sugda, Uvarazamiya, Thatagus, Harauvatis, India, Ga(n)dara, Saka, Maka. Says Darius the king if thus thou shalt think "may I not fear an enemy," protect this Persian state; if the Persian state shall be protected, may this goddess (namely) this spirit (of patriotism) for a long time unharmed, descend upon this race.

C.

Over the pillars in the palace.

Darius the great king, king of kings, king of the countries, the son of Hystaspes, the Achaemenide, who built this palace.



The Tomb of Darius.

THE INSCRIPTION ON THE TOMB OF DARIUS.

Naqshi—Rustam is the burial place of Darius.

On the face of a mountain which rises to the perpendicular height of 900 feet are cut the excavations which are doubtless tombs. These relics have a common external appearance. They are carved into the rock fourteen feet deep in the form of a cross the upright section of which is about ninty feet, the tranverse division about fifty feet. Four pilasters about seven feet apart ornament the tranverse section, in the midst of which is the door of the tomb. On the division above the facade of this sepulchre are the sculptures. A double row of fourteen figures support two cornices. Two bulls form the pillars at each end of the upper cornice. On an elevated pedestal of three steps stands a figure dressed in a flowing robe holding his bow in his left hand. Without doubt this is the effigy of him who lies buried beneath. Opposite the standing form on a pedestal of three steps is an altar upon which the sacred fire is burning, while above is a disk probably representing the sun of which the fire blazing at the shrine is the symbol. Above is the image of Auramazda. One of these structures Ker-Porter visited and with great difficulty explored its interior. Although he was not able to read the inscription, yet he conjectured that this was the tomb of Darius. I quote him at this point. "The second tomb is the only one whereon the marks of an inscription can be traced; but over the whole tablet of the upper compartment, letters are visible wherever they could be introduced; above the figures, between them and the altar, along the side, from top to bottom,' in short, everywhere, we see it covered with the arrow-headed characters and in good preservation. What a treasure of information doubtless is there to the happy man who can decipher it. It was tantalizing to a painful degree, to look at such a sealed book, in the very spot of mystery, where probably, its contents would explain all. But it certainly is a very distinguishing peculiarity of this tomb that it alone should contain any inscription, and that the writing on it is so abundant; a circumstance that might warrant the supposition of this being the tomb that was cut by the express orders of Darius Hystaspes to receive his remains." (Travels in Georgia, Persia, Armenia, ancient Babylonia etc. etc. by Sir Robert Ker-Porter, vol. I, p. 523).

Before translating the inscription I wish to call the attention of the reader to Herod III. 88. *πρῶτον μέν νυν τύπον ποιησάμενος λίθινον (Δαρεῖος) ἔστησε. ζῷον δέ οἱ ἐνῆν ἀνὴρ ἱππεύς. ἐπέγραψε δὲ γράμματα λέγοντα τάδε. Δαρεῖος ὁ Ὑστάσπεος σύν τε τοῦ ἵππου τῇ ἀρετῇ καὶ Οἰβάρεος τοῦ ἱπποκόμου ἐκτήσατο τὴν Περσέων βασιληίην.*

A.

A great god is Auramazda, who created this earth, who created yonder heaven, who created man, who created the spirit? of man, who made Darius king, one king of many, one lord of many. I (am) Darius the great king king of kings, king of the countries possessing many kinds of people, king of this great earth far and wide, son of Hystaspes the Achaemenide, a Persian, the son of a Persian, an Aryan, an Aryan offspring. Says Darius the king by the grace of Auramazda these (are) the provinces which I seized afar from Persia; I ruled them; they brought tribute to me.....what was commanded to them by me, this they did; the law which (is) mine, that was established; Media, Uvaja, Parthia, Haraiva, Bactria, Suguda, Uvarazamis, Zara(n)ka, Harauvatis, Thatagus, Ga(n)dara, India, Sakae Humavarkae, Sakae Tigrakhaudae, Babylon, Assyria, Arabia, Egypt, Armenia, Cappadocia, Sparda, Ionia, Sakae beyond the sea, the Ionians wearing long hair,* Patians, Kusians, Macians, Karkians. Says Darius the king Auramazda, when he saw this earth ....afterwards gave it to me: he made me king; I am king; by the grace of Auramazda I established it on (its) foundation; what I commanded to them, this they did as desire came to (lit. was) me. If perchance thou shall think that manifold (lit. a manifold thing) are these provinces which Darius the king held, look at the picture (of those) who are bearing my throne,† in order that thou mayst know them; then to thee will be the knowledge (that) the spear of a Persian man hath gone forth afar; then to thee will be the knowledge (that) a Persian man waged battle far from Persia. Says Darius the king this (is) what (was) done; all this by the grace of Auramazda I did; Auramazda bore me aid until this (was) done; let Auramazda protect me from ..... and my race and this country; this I pray of Auramazda; this let Auramazda give me: O man, what (are) the commands of Auramazda, may he (make them) revealed to thee; do not err; do not leave the right path; do not sin.

B.

A great god (is) Auramazda who ..... made spirit? of man.....above Darius the king ....Says Darius the king by the

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*Cf. the Homeric καρηκομωοντες.

† The northern throne of the great palace contains five tiers of ten warriors supporting the platform on which the king is represented sitting, surrounded by his attendants.

grace of Auramazda.....
.....
.....
..... is violence .....
.....
..... violence .....

C.

Gaubaruva, a Patisuvarian, spear-bearer of Darius the king.

D.

Aspacana, quiver-bearer?, a server of the arrows of Darius the king.

E.

This (is) a Macian.

THE INSCRIPTIONS OF XERXES AT PERSEPOLIS.

A.

Upon each one of the four pillars of the entrances to the palace of Xerxes

A great god (is) Auramazda who created this earth, who created yonder heaven, who created man, who created the spirit? of man, who created Xerxes king, one king of many, one lord of many. I (am) Xerxes the great king, king of kings, king of the countries, possessing many kinds of people, king of this great earth far and wide, the son of Darius the king, the Achaemenide. Says Xerxes the great king by the grace of Auramazda, this entrance possessing all countries I made; much else (that is) beautiful (was) done by this Persian (people) which I did and which my father did; whatever (that has been) done seems beautiful, all that we did by the grace of Auramazda. Says Xerxes the king let Auramazda protect me and my kingdom and what (was) done by me and what (was) done by my father, (all) this let Auramazda protect.

B.

Upon the pillars on the western side of the palace, where Xerxes is represented standing with two attendants.

Xerxes the great king, king of kings, the son of Darius the king, the Achaemenide.

C.

Upon the wall by the stairs of the palace.

A great god (is) Auramazda who created this earth, who created yonder heaven, who created man, who created the spirit ? of man, who made Xerxes king, one king of many, one lord of many. I (am) Xerxes the great king, king of kings, king of the provinces possessing many kinds of people, king of this great earth far and wide, son of Darius the king, the Achaemenide. Says Xerxes the great king by the grace of Auramazda this palace (lit. seat) I made; let Auramazda protect me with the gods and my kingdom and what (was) done by me.

D.

The above inscription is repeated on the western stairs of the palace.

E.

Upon the highest pillar near the southern stairs.

A great god (is) Aurmazda who created this earth, who created yonder heaven, who created man, who created the spirit ? of man, who made Xerxes king, one king of many, one lord of many. I (am) Xerxes the great king, king of kings, king of the provinces possessing many kinds of people, king of this great earth far and wide, son of Darius the king, the Achaemenide. Says Xerxes the great king by the grace of Aura * Mazda this palace (lit. seat) Darius the king made who (was) my father; let Auramazda protect me with the gods and what (was) done by my father Darius the king, (all) this let Auramazda protect with the gods.

F.

The above inscription is repeated upon the walls of the southern stairs.

G.

Upon the stairs of the palace.

A great god (is) Auramazda who created this earth, who created yonder heaven, who created man, who created the spirit? of man, who made Xerxes king, one king of many, one lord of many. I (am) Xerxes the great king, king of kings, king of the provinces possessing many kinds of people, king of this great earth far and wide, the son of Darius the king, the Achaemenide. Says Xerxes the great king what (was) done by me here and what (was) done by me afar, all this I did by the grace of Auramazda; let Auramazda protect me with the gods and my kingdom and what (was) done by me.

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* Notice that the two members of the compound are separated. In the Zend Avesta we read AHURA MAZDA, AURA signifies *lord* (Cf. Sanskrit ASURA, Zend AHURA); MAZDA we can divide into MAZ *great* (Cf. Sanskrit MAHAT, Lat. MAG-NUS, Gothic MAG, Eng. MIGHT.) and DA *to know*.

THE INSCRIPTION OF XERXES AT ALVEND.

The following inscription is engraven upon two niches cut into a small rock:

A great god (is) Auramazda, who (is) greatest of the gods, who created this earth, who created yonder heaven, who created man, who created the spirit? of man, who made Xerxes king, one king of many, one lord of many. I (am) Xerxes the great king, king of kings, king of the provinces possessing many kinds of people, king of this great earth far and wide, the son of Darius the king, the Achaemenide.

THE INSCRIPTION UPON THE VASE OF COUNT CAYLUS.

This vase contains the three customary forms of cuneiform writing and a line of Egyptian hieroglyphics. This relic is preserved in Paris. Four fragments of similar alabaster vases containing the same quadrilingual inscription have been found by W. K. Loftus in Susa, and are to be seen to-day in the British Museum.

I (am) Xerxes, the great king.

THE INSCRIPTION AT VAN.

This inscription is about sixty feet from the plain below, engraven upon a niche in an enormous rock which rises to the perpendicular heighth of one hundred feet:

A great god (is) Auramazda who (is) the greatest of the gods, who created this earth, who created yonder heaven, who created man, who created the spirit? of man, who made Xerxes king, one king of many, one lord of many. I (am) Xerxes the great king, king of kings, king of the provinces possessing many kinds of people, king of this great earth far and wide, the son of Darius the king, the Achaemenide. Says Xerxes the king Darius the king who (was) my father he by the grace of Auramazda did what (was) beautiful to a great extent and he commanded to carve this place——? he did not make the inscription inscribed; afterwards I commanded to inscribe this inscription; let Auramazda protect me with the gods and my kingdom and what (has been) done by me.

THE INSCRIPTION OF ARTAXERXES I.

This inscription, which is quadrilingual is engraven upon a vase which is preserved in the treasury of St. Mark's at Venice.

Artaxerxes,* the great king.

THE INSCRIPTION OF DARIUS II.

Above the posts of the windows in the palace at Persepolis.

(This) lofty stone structure (has been) made by (one belonging to) the race of Darius the king.

THE PECULIARITIES OF INSCRIPTIONS OF ARTAXERXES MNEMON AND ARTA XERXES OCHUS.

These inscriptions show that the work of decay had already begun in the grammatical structure of the language. Such careless irregularities occur in them that I wish to call the attention of the reader to a few before I begin the translation: (1) what should be a genitive becomes attracted into the nominative on account of proximity; (2) the nominative is attracted into the case of a preceding noun for the same reason, yet allowing the predicate to be in the proper case; (3) the nominative is thrust into the accusative as if it were to become a direct object, yet the passive construction is retained. In consequence of these irregularities it will be impossible to make a literal translation as I have done heretofore, but I shall translate as if the regular constructions were employed.

* The cuneiform text spells the name of the monarch on the vase ARDAKHCASHCA. This spelling must be due either to foreign pronunciation or to the ignorance of the workman, Elsewhere the cuneiform characters give the regular ARTAKHSHATRA.

THE INSCRIPTION OF ARTAXERXES MNEMON AT SUSA.

This inscription is upon the base of one of the columns in the ruins of what once must have been a great palace. Much of this building was used for the pavement of other edifices by the races which in after time possessed this spot.

A.

I (am) Artaxerxes, the great king, king of kings, the son of Darius* the king.

B.

Upon the base of a pillar in a large row of columns. This palace seems to have been fashioned after the model of that of Darius at Persepolis. In connection with this edifice it is interesting to refer to Dan. viii. 2. "and it came to pass when I saw, that I was in Susa (or Shushan) in the palace" etc.

Says Artaxerxes the great king, king of kings, king of the countries, king of the earth, the son of Darius the king; Darius (was) the son of Artaxerxes the king; Artaxerxes (was) the son of Xerxes the king; Xerxes (was) the son of Darius the king; Darius (was) the son of Hystaspes, the Achaemenide; this building Darius, my ancestor made..... .....Artaxerxes (my) grandfather.....Anakata and Mithra.....by the grace of Auramazda the building I made; let Auramazda, Anahata and Mithra protect me.....

* DARAYAVUS (Darius) although having a stem in U is treated like nouns whose stems end in A. So in Prakrit there is a strong tendency for the so-called first declension to trespass upon the others, thus breaking down the barriers which were observed by the Sanskrit.

THE INSCRIPTION OF ARTAXERXES OCHUS AT PERSEPOLIS.

Upon the steps of the palace.

A great god (is) Auramazda who created this earth, who created yonder heaven, who created man, who created the spirit? of man, who made me, Artaxerxes, king, one king of many, one lord of many. Says Artaxerxes the great king, king of kings, king of countries, king of the earth. I (am) the son of Artaxerxes, the king; Artaxerxes (was) the son of Darius the king; Darius (was) the son of Artaxerxes the king; Artaxerxes (was) the son of Xerxes the king; Xerxes (was) the son of Darius the king; Darius was the son of Hystaspes by name; Hystaspes was the son of Arshama by name, the Achaemenide. Says Artaxerxes the king this lofty stone structure (was) made by me during my reign (lit. under me). Says Artaxerxes the king let Auramazda and the god Mithra protect me and this country and what (was) done by me.

THE OLD PERSIAN LANGUAGE.

We have now translated all the inscriptions of the Achaemenides which have been discovered. Before closing this work I wish to speak a word for the Old Persian language. Not only the historian feels an interest in reading the records written by the monarchs of one of the greatest empires of past ages, but the philologist recognizes in the speech, which has been preserved to us through the ambition of these oriental despots another offspring of our mother-tongue. Of that great sisterhood of languages, to which our own speech belongs, the Old Persian is a most ancient member. In its grammatical structure it most closely resembles the Vedic dialect of the Sanskrit and we have to rely almost entirely upon the combined help of the Sanskrit and Zend for an understanding of its vocabulary. For the sake of illustration I add a few Old Persian words with their cognates in the other members of our family.

Old Persian.	Sanskrit.	Zend.	Greek.	Latin.	Gothic.	English.
AITA.	ETAT.	AETAD.	τό.	ISTE.	THA.	THE.
UPARIY.	UPARI.	UPARA.	ὑπέρ.	super.	UFAR.	OVER.
TUVM.	TVAM.	THWAM.	σύ (τύ).	TU.		THOU.
GAM.	GAM.	GAM.		VENIO.	QUAM.	COME.
PITAR.	PITAR.	PITA.	πατήρ.	PATER.	FADAR.	FATHER.

In its phonetic system the Old Persian showed a striking analogy to that of the Greek in allowing an original sibilant to pass over into the aspiration. e. g. AH *be* for Skt. AS.; so in Greek ὁ and ἡ for Skt. SAS and SA.

A few peculiar points of syntax I shall note.* The nominative is sometimes used apparently as the direct object of a verb. The instrumental assumes a temporal sense by denoting the association of time with an event. The dative has disappeared from the language and its place is taken by the genitive. This datival genitive is simply a pregnant use of the possessive genitive and occurs likewise in the Prakrit and late Sanskrit. e. g. KHSHATRAM MANA FRABARA, he gave the kingdom to me (made

* For a fuller discussion of the peculiarities of Old Persian syntax, cp. my article in the Proceedings of the Oriental Society (1892) p. 100.

it mine by giving). The relative pronoun is frequently equivalent in meaning and usage to the Greek article agreeing with its antecedent not only in gender and number but also in case. When used in this way its independent character is lost.

The imperfect and aorist sometimes appear without augment as often in the Veda. With the loss of this augment they sacrifice their peculiar character. After MA prohibitive the sense is that of an optative or imperative. The infinitive often expresses purpose as the dative infinitive in the Rig Veda.

The participle of KAR *do* regularly takes a genitive for the instrumental, perhaps on account of the nominal character of the participle.

THE EFFECTS OF CHANGES IN TEMPERATURE ON THE DISTRIBUTION OF MAGNETISM.

By HIRAM B. LOOMIS, Ph. D.,

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The following paper is an account of some experiments undertaken to determine more accurately, if possible, the kind of change which takes place when a magnet is heated and cooled. An extensive investigation of the changes in magnetic distribution, moment, and permeability is under way and considerable work has been done in all three lines. Though the results so far obtained as to changes in moment and permeability are not deemed complete enough for publication, the investigation as to the changes in distribution may be of interest.

The subject will be considered under the following heads:

I. Historical Sketch.
II. Description of Apparatus and Experiment.
III. Calculation and Verification of Results.
IV. Discussion of Results.

I. HISTORY.

* About 1825, Kupffer magnetized a steel bar and placed it in a water bath. Near it he suspended a magnetic needle and determined the period of 300 swings before the temperature of the bar had changed. The bath was then heated to 100° C., and the period of 300 swings again determined. The bar was alternately heated and cooled between the same limits of temperature, and determinations of the period were made. His results may be summed up as follows: If a permanent magnet be heated above the temperature of magnetization, its magnetic moment decreases. On again cooling the moment increases, but not enough to make up the first loss. This is true of the first three or four heatings and coolings.

† Riess and Moser also experimented on the change in magnetic moment by swinging magnets in the earth's field and determining the period of

* Wiedemann's Electricität III., p. 753.

† Riess und Moser, Pogg. Ann. 17, p. 425, 1829.

vibration. For needles 34 lines long they found the following formula held:

$$I' = I\,[1 - 0.000324\,(t' - t)\,d],$$

where I and I' are the intensities of magnetization at the temperatures t and t' on the Reamur scale, and d is the diameter of the magnets. For needles 2 inches long the numerical factor is 0.000432, showing that the proportional change in intensity of magnetization is greater in shorter magnets. Their temperature limits were 0° and 80° R. By swinging their magnets at different temperatures they found the change in moment proportional to the difference in temperature as is shown by their formula, which is to be applied with caution for their magnets had not been brought to what we call the permanent state.

In 1851,* Lamont found that when a permanent magnet was alternately heated and cooled fifteen or sixteen times between fixed limits of temperature, it reached a permanent state in which it had a definite magnetic moment for a given temperature and always returned to that moment when brought to the corresponding temperature, provided only it had never passed beyond the temperature limits mentioned above. The higher the temperature, the smaller was the magnetic moment.

†Prof. G. Wiedemann has made some careful investigations on the influence exerted by the temper of the steel and the original intensity of magnetization. He used bars 22 cm. long and 1.35 cm. in diameter. Before being magnetized, they were alternately placed in melting snow and boiling water fifteen times, in order to bring the steel itself as far as possible into such a state that alterations in temperature would produce no structural change. The bars were magnetized in a coil at a temperature of 0°. They were then carefully placed in a box of sheet copper before the needle of a magnetometer and the deflection was observed by a telescope and scale. The temperatures of 0° and 100° C. were obtained by means of melting snow and boiling water. His results for magnets that have reached the permanent state show that in the case of hard steel magnets the change in moment is nearly proportional to the moment at 0°, while for tempered and soft steel magnets, the ratio of the change to the moment at 0° C. increases with the moment. As his results give a good idea of the size of the changes under discussion, I append the following table from his paper:

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* Lamont, Pogg. Am. 82, p. 440, 1851.

† G. Wiedemann, Pogg. Am. 100, p. 235, 1852; 103, p. 563, 1858; 122, p. 355, 1664.

M_0	M_{100}	M'_0	N_0	N_{100}	$\frac{M_0-M_{100}}{M_0}$	$\frac{M_0-M'_0}{M_0}$	$\frac{M_0-N_0}{M_0}$	$\frac{N_0-N_{100}}{N_0}$
				I. *Hard steel bar.*				
71.5	41.5	44.8	37.	33.2	0.420	0.373	0.483	0.103
134.5	89.2	96.	85.5	77.8	0.321	0.286	0.364	0.090
195.	134.3	146.2	133.3	120.	0.311	0.250	0.316	0.100
				II. *Tempered steel bar.*				
44.	27.	30.	29.	27.	0.386	0.318	0.341	0.0690
148.5	107.2	114.5	110.3	101.	0.278	0.229	0.257	0.0814
219.5	165.	179.	172.	156.	0.249	0.184	0.216	0.0930
317.	239.	260.7	251.2	226.	0.246	0.178	0.207	0.1003
				Soft steel bar, No. 1.				
85.	45.	.....	38.	33.2	0.471	.....	0.553	0.126
141.	73.5	.....	68.5	57.	0.479	.....	0.514	0.168
193.	99.	.....	101.	78.5	0.487	.....	0.478	0.223
209.5	109.5	.....	115.	88.2	0.477	.....	0.451	0.233
				Soft steel bar, No. 2.				
95.5	49.7	54.2	45.	39.	0.479	0.432	0.529	0.133
136.5	73.	81.5	69.	59.	0.465	0.403	0.495	0.145
174.8	92.5	108.3	93.4	76.	0.471	0.378	0.466	0.186
				Very soft steel bar which had been heated and slowly cooled many times.				
51.5	34.5	37.	.....	.....	0.330	0.282	.....	.....
80.5	54.5	58.	.....	.....	0.323	0.279	.....	.....
113.	76.	82.	.....	.....	0.328	0.274	.....	.....
159.5	103.3	116.5	.....	.....	0.353	0.270	.....	.....
181.	113.5	131.	.....	.....	0.373	0.277	.....	.....

M_0 is the intensity of magnetization before any change in temperature has taken place; M_{100}, when first heated to 100° C.; M'_0, after being again cooled to 0° C. N_0 and N_{100} are the intensities of magnetization at the temperatures indicated by the subscripts after the magnet has been heated and cooled fifteen times.

With reference to the theory of these changes Prof. Wiedemann says: "Besides the permanent effect due to an alteration in temperature there is a temporary change. Each heating diminishes the permanent moment of the molecules. Moreover, for the time being, it loosens the particles of the body and lessens the strain in which they have been placed by the action of external forces, therefore they return a little toward their first position of equilibrium, in which they were held by the forces acting between them before the external forces came into play. Heating thus diminishes the magnetization temporarily, but on cooling the molecules return to their former position and the lost magnetization is regained.

"We can produce entirely analogous phenomena if we change the temperature of bodies which have suffered a change of form (tortion) as a result of the mechanical forces, and observe the increase and decrease of this on heating and cooling."

*Barus and Strouhal carefully distinguished the mechanical effect of heating from the purely magnetic effect. They found that a temperature 20° or 30° C. above that of the water in which a glass hard steel rod was dipped in hardening produced quite perceptible annealing effects. This change in the hardness of steel would naturally affect the magnetization.

According to their exprriments, if a glass hard steel rod is thoroughly annealed by being kept at the temperature of boiling water for a day or two and then magnetized to saturation at the temperature of the room, the loss in magnetism on being heated to the boiling point is relatively small and is nearly independent of the time it is kept there. Nearly the whole change takes place during the first ten minutes. On the other hand, if the bar is not first annealed, the change is much larger and is not complete after twenty-two hours heating.

We pass now to investigations on changes in distribution due to temperature changes. This field has not been extensively worked. These two investigations are all that could be found.

†Kupffer determined at two different temperatures the period of vibration of a short needle placed opposite different parts of a long magnet, and found the proportional change in distribution greater at the ends than in the middle of the bar. All his measurements were made before the bar had reached the permanent state.

‡Poloni measured the distribution at various temperatures, by slipping a coil from different parts of the magnet to such a distance that the magnet exerted practically no effect, and measuring the quantity of electricity thus induced. He worked between temperatures 0° and

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* Bull U. S. Geol. Sur. No. 14, p. 151.

† Kuppfer, Pogg. Ann. 12, p. 133.

‡ Poloni, Beibl. 5, p. 802. Atti della R. Acad. del Lincei 5, p. 262, 1881.

200° C., using an oil bath to obtain his high temperatures. The changes were quite regular between 0° and 180° C., but were very large near 190° C. Between 0° and 180° C., he found that the following formula held:

$$M = A \left[1 + K^{-l} - K^{-x} - K^{(l + x)} \right]$$

where M is the induction in the magnet at a distance x from one of the ends; l, the length of the magnet; A, a quantity depending only on the temperature, while K is sensibly constant for a given magnet.

II. DESCRIPTION OF APPARUTUS AND EXPERIMENT.

The determination of the reason for and laws governing the increase and decrease in magnetism from changes in temperature forms an interesting problem, and the investigation was undertaken in the hope of throwing new light on the subject. The apparatus employed was suggested by Prof. Rowland, under whose direction the investigation was conducted, and will be best understood from the diagram on plate XI.

A and B are two cylindrical soft steel magnets (Stub's steel of the same temper as when purchased) 30.1 cm. long, and 0.55 cm. in diameter. They were magnetized to saturation in a coil, the magnetic circuit being completed by an iron casting, which happened to be of suitable size and shape. They were then brought to the permanent state by alternate heating and cooling. In both ends of each holes were bored and threads cut. The depth of these holes in magnet A was 8 mm. at each end. In magnet B the hole at the south end was 11 mm. deep, that at the north end 7 mm. In the experiment the magnets were placed perpendicular to the earth's field.

Pieces of brass rod H H H H of the same diameter as the magnets were screwed into their ends and acted as guides for the two coils (to be described presently), so that after they had been slipped off the magnets, they could be slipped back again without trouble. DD is a brass rod about 1.5 metres long, holding the two magnets together in the position shown in the figure. CC are pieces of non-conducting material to keep the magnets from changing temperature by conduction along the rod DD.

E and F are two coils of very fine wire wound on paper tubes which just fit the magnets. They consisted of 150 turns (five layers of thirty turns each), and were about 7 mm. wide. Their frames were joined by a brass rod PP, of such length that when the coil E was at the center of the magnet B, the coil F was also at the center of the magnet A. By

means of this rod they could be moved simultaneously over corresponding portions of the two magnets. At G is a gauge which regulates the distance the coils are moved at a time, so that as they are moved step by step from one end of the bar to the other, the steps will be of equal length. By loosening a screw the coils may be moved from the middle of the magnet to either end at one step.

The cross sections of two cylindrical double boxes made of sheet zinc are indicated at S and T. At K K are openings in which corks holding thermometers were inserted. At L L are openings into the space between the two parts of the double box. Through these a current of steam or cold water was passed to keep the space containing the magnets at the requisite temperature. The temperatures employed were 14° and 99.5° C. The water used to produce the lower temperature was city water direct from the faucet. A fairly constant temperature was easily maintained. M N, M N, are openings by which the magnets were introduced and through which the bars D D and PP passed. They were about 2.5 cm. in diameter and 20. cm. long, und were stuffed with cotton, the better to maintain the temperature of the interior.

The exploring coils, an ordinary astatic galvanometer of low resistance, an earth inductor, and a resistance box were connected up in series. At first the exploring coils were so joined that the currents produced by moving them opposed each other. Beginning at the middle of the magnets the coils were moved step by step to one end, the throw of the needle being observed for each step. The coils were moved so far in the last measurment that practically no lines of induction passed through them as was determined by experiment. Similar observations were made for the other half of the magnets. This gives the excess of the number of lines of induction passing from a certain section of one magnet into the air over that passing out of a corresponding section of the other magnet, that is the difference of distribution of magnetism in the two magnets. These measurments are taken first (say) when A and B are both at 14°C, and and again when A is at 14°C, but B at 99.°5 C. The difference between the two sets after they have been reduced to the same scale by the earth inductor readings is evidently the change in distribution in B due to the change in the temperature. By this method the quantity observed is of about the same magnitude as the quantity we desire to obtain.

To get the distribution of magnetism of the bars, the difference in distribution was first measured as above at the lower temperature, then the connections of the coils were changed so that the induced currents were in the same direction and the sum of the distributions was measured in a similar way. In this case extra resistance had to be added from the resistance box to keep the readings on the scale.

III. CALCULATING OF RESULTS.

The formula for the ballistic galvanometer is

$$Q = k \sin \frac{\vartheta}{2}$$

where Q is the quantity of electricity; k, a constant factor; and ϑ the angular throw of the needle. The observations were made with telescope and scale. Calling d the observed throw and r the distance of the mirror from the scale.

$$\tan \; 2 \; \vartheta \; = \; \frac{d'}{r}$$

Expanding $\sin \frac{\vartheta}{2}$ we have

$$\text{Sin} \; \frac{\vartheta}{2} \; = \; \frac{d}{2r} \left[\; 1 - 0.344 \; \left(\frac{d}{r}\right)^2 + \; \right] \; ;$$

this formula was used in reducing the large readings.

The earth inductor readings were taken frequently and were substantially the same throughout the experiment. The throw of the needle due to the earth inductor when both magnets were at 14° C. was 39.5 scale divisions; when one magnet was at 99.°5 C. and the other at 14° C., it was 37.8. The average throw due to slipping the exploring coils over a certain portion of the magnets when one was hot and the other cold, was multiplies by $\frac{39.5}{37.8} = 1.045$ to reduce to the scale of readings taken when both magnets were cold. Corresponding readings were then subtracted, giving the change in distribution in terms of the scale divisions. The reduction to absolute measure was as follows: The effective area of the earth inductor as determined by previous observers is 20,716 sq. cm. The value of the horizontal component of the earth's field at and near the position in which the earth inductor was placed has been determined by numerous observers, and by various methods, and may safely be taken as within 1 per cent. of 0. 2 C. G, S units. The total number of lines of induction cut by turning the earth inductor was 2 H A = 8,286.4. As the throw was 39.5 scale divisions, each division correspouded to $8{,}286.4 \div (39.5 \times 150) = 1.398$ C. G. S. lines of induction. The factor 150 is due to the 150 turns of the exploring coils. The change in distribution in scale divisions obtained above was then multiplied by 1.398 giving the change in linear distribution in C. G. S. lines of induction per 2.17 cm., that being the distance the coils were moved at each step.

In determining the difference in distribution, the angles observed were quite small. The largest was less than 2°, making the angular throw of the needle less than 1°. The deflections in scale divisions were therefore taken as proportional to sin $\frac{\vartheta}{2}$. The error in the case of the largest reading would not exceed one part in 3,500. The error in the result is still less, as it is obtained by subtracting two throws.

SPECIMEN CALCULATION.

Magnet A.

Middle to North End.

Steps.	Average observed throw at 14° C.	Average observed throw at 99.°5 C.	Corrected throw at 99.°5 C.	Difference in distribution in scale divisions.	Difference in distribution in C. G. S. lines of inductions.
I.....	18.0	17.5	18.3	— 0.3	— 0.4
II.....	18.4	18.1	18.9	— 0.5	— 0.7
III.....	11.8	12.6	13.2	— 1.4	— 2.0
IV.....	— 7.2	— 4.2	— 4.4	— 2.8	— 3.9
V.....	— 34.3	— 27.2	— 28.4	— 5.9	— 8.3
VI.....	— 42.0	— 27.7	— 28.9	— 13.1	— 18.3
VII.....	— 49.0	— 19.4	— 20.3	— 28.7	— 40.2
End.....	— 5.1	— 2.2	— 2.3	— 3.1	— 4.3

In finding the sum of the distributions it was found necessary to make use of the formula given on p. 279, because the angles were too large to take sin $\frac{\vartheta}{2}$ proportional to tan 2 ϑ. The corrected readings were reduced to absolute measure in the way just described. We have now the sum and difference of the linear distribution of the two magnets. One-half the sum plus one-half the difference gives the distribution of one, one-half the sum minus one-half the difference gives that of the other. The distributions at the higher temperature were obtained by subtracting the change in distribution due to the heating.

The induction at each point of the magnet was obtained by adding up the number of lines of induction passing out of the magnet beyond the point in question.

Tables of the results for magnets A and B are given on pages 282–83. The first column gives the distance of the exploring coils from the centers of the magnets at the end of each step. The second and fourth columns gives the number of C. G. S. lines of induction passing out from the magnet at 14° and 99.°5 C. respectively in the step of the coil shown in the first column. The third column gives the change in distribution. The fifth and sixth columns gives the magnetization at the two temperatures, i. e. the number of C. G. S. lines of induction per square centimeter passing through the magnet at the point indicated. The seventh column gives the proportional change in magnetization at different points of the magnet.

In the fifth and sixth columns two values are given for the center of the magnet, calculated from the two ends, and serve to indicate the degree of accuracy attained. The variation is considerably less than one per cent. The second and third columns from which all the others are calculated give the means of at least five or six separate determinations, which agree well among themselves. The results were further checked by slipping the coils from the middle of the magnet clear off each end at both temperatures. The variation between this measurement and the others was always less than one-half of one per cent. This was considered quite good as it is impossible to slip the coils over this whole distance at the same rate at which they were slipped over the small divisions.

In plate XI our results are shown graphically. The full lines give the distribution at 14° C and 99.°5 C. The dotted lines give the change in distribution due to this change in temperature. The scale of ordinates in the last curves is ten times that of the distribution curves.

In addition to the checks upon accuracy already mentioned, the following entirely independent determinations of the magnetic moments of the two magnets were made. In the tables of distribution pp. 282–83, we are given the number n of lines of induction issuing from little divisions of the bar, as well as the distance d of these divisions from the center of the magnet. A first approximation to the moment is given by the formula:

$$M = \frac{1}{4\pi} \Sigma \text{ nd.}$$

Magnet A.

Distance from center of magnet.	Distribution at 14° C.	Change in distribution.	Distribution at 99°.5.	I_{14} Induction at 14° C.	$I_{99.5}$ Induction at 99°.5.	$\frac{I_{14}-I_{99.5}}{I_{14}}$
.....	70.1	— 4.3	65.8	.....	.....	.....
15.20	.....	.....	.....	296.	278.	.060
.....	428.5	—40.2	388.3	.....	.....	.....
13.03	.....	.....	.....	2106.	1918.	.089
.....	285.4	—18.3	267.1	.....	.....	.....
10.86	.....	.....	.....	3309.	3044.	.080
.....	204.9	— 8.3	196.6	.....	.....	.....
8.68	.....	.....	.....	4175.	3875.	.071
.....	146.8	— 3.9	142.9	.....	.....	.....
6.51	.....	.....	.....	4795.	4479.	.065
.....	91.2	— 2.0	89.2	.....	.....	.....
4.34	.....	.....	.....	5180.	4586.	.062
.....	56.6	— 0.7	55.9	.....	.....	.....
2.17	.....	.....	.....	5419.	5092.	.060
.....	18.6	— 0.4	18.2	{5498.	{5169}	.....
0	.....	.....	.....	5453.}	5126}	.060
.....	— 17.9	0.	— 17.9	.....	.....	.....
2.17	.....	.....	.....	5377.	5050.	.060
.....	— 55.5	+ 0.4	— 55.1	.....	.....	.....
4.34	.....	.....	.....	5143.	4818.	.063
.....	— 96.9	+ 2.5	— 94.4	.....	.....	.....
6.51	.....	.....	.....	4734.	4420.	.066
.....	—142.1	+ 3.2	—138.9	.....	.....	.....
8.68	.....	.....	.....	4134.	3834.	.072
.....	—199.9	+ 6.2	—193.7	.....	.....	.....
10.86	.....	.....	.....	3289.	3015.	.083
.....	—276.3	+14.8	—261.5	.....	.....	.....
13.03	.....	.....	.....	2122.	1910.	.100
.....	—432.6	+39.2	—393.4	.....	.....	.....
15.20	.....	.....	.....	294.	247.	.159
.....	— 69.7	+11.2	— 58.5	.....	.....	.....

Magnet B.

Distance from center of magnet.	Distribution at 14°	Change in distribution.	Distribution at 99.°5.	I_{14} Induction at 14°.	$I_{99.5}$. Induction at 99.°5.	$\frac{I_{14}-I_{99.5}}{I_{14}}$.
.....	61.0	— 3.9	+ 57.1	.....	.....	.....
15.20	.....	.....	.....	258.	242.	.062
.....	359.5	— 39.6	+ 319.9	.....	.....	.....
13.03	.....	.....	.....	1777.	1594.	.103
.....	227.6	— 15.1	+ 212.5	.....	.....	.....
10.86	.....	.....	.....	2738.	2491.	.090
.....	159.7	— 6.0	+ 153.7	.....	.....	.....
8.68	.....	.....	.....	3413.	3141.	.079
.....	139.4	— 3.4	+ 136.0	.....	.....	.....
6.51	.....	.....	.....	4002.	3716.	.071
.....	108.1	— 2.1	+ 106.0	.....	.....	.....
4.34	.....	.....	.....	4458.	4163.	.066
.....	81.4	— 1.5	+ 80.0	.....	.....	.....
2.17	.....	.....	.....	4802.	4501.	.062
.....	43.5	— 0.1	+ 43.4	.....	.....	.....
	.....	.....	.....	4986. 4950.	4685. 4650.	.060
.....	3.6	+ 0.7	+ 4.3	.....	.....	.....
2.17	.....	.....	.....	4965.	4668.	.060
.....	— 36.2	+ 1.1	— 35.1	.....	.....	.....
4.34	.....	.....	.....	4812.	4520.	.060
.....	— 79.8	+ 2.0	— 77.8	.....	.....	.....
6.51	.....	.....	.....	4475.	4191.	.063
.....	— 128.3	+ 2.4	— 125.9	.....	.....	.....
8.68	.....	.....	.....	3933.	3659.	.069
.....	— 188.6	+ 6.6	— 182.0	.....	.....	.....
10.86	.....	.....	.....	3136.	2890.	.078
.....	— 266.3	+ 19.0	— 247.3	.....	.....	.....
13.03	.....	.....	.....	2011.	1845.	.082
.....	— 406.4	+ 35.4	— 371.0	.....	.....	.....
15.20	.....	.....	.....	294.	277.	.057
.....	— 69.7	+ 4.1	— 65.6	.....	.....	.....

To this value the following correction was added: If A B, in Fig. 1, is the length of one of these divisions of the magnet, and C D a part of

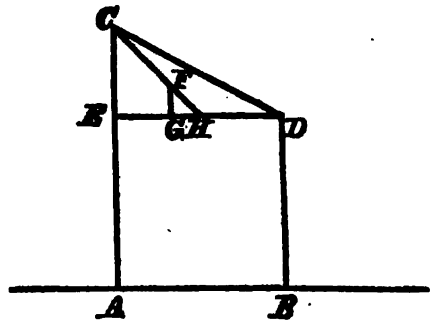

FIG. 1.

the distribution curve supposed to be straight, then the area A B D C represents the number of lines of induction issuing from the magnet in the length A B. Let F be the center of gravity of the triangle C E D. It is evident that the portion of the distribution represented by the triangle should be multiplied by the abscissa of F, not of H, therefore a correction

$$\Sigma \text{ area of } C\,E\,D \times G\,H$$

was added to the summation already given. From this calculation the following results were obtained:

	Magnets.	A.	B.
M_{14}	Moment at 14° C	2298	2060
$M_{99.5}$	Moment at 99.°5 C	2140	2018
$M_{14} - M_{99.5}$	Loss	158	142
$\frac{M_{14} - M_{99.5}}{M_{14}}$	Proportional loss	0.0687	0.0689
	Intensity at 14° C	322	289
	Intensity at 99.°5 C	300	283

The magnetic moments were also determined by swinging the magnets at the two temperatures in a known field. The experiments were performed with great care and gave the following results:

	Magnets.	A.	B.
M_{14}	Moment at 14° C.	2359	2091
$M_{99.5}$	Moment at 99.°5 C.	2197	1947
$M_{14}-M_{99.5}$	Loss	166	146
$\frac{M_{14}-M_{99.5}}{M_{14}}$	Proportional loss	0.0686	0.0687
	Intensity at 14° C.	339	298
	Intensity at 99.°5 C.	316	277

The difference between these two sets of values is considerable, in the case of magnet A the variation amounts to two per cent. This may be due to the fact that only an approximation could be made to the moments of inertia of the magnets because of the holes in the ends, where a slight error would affect the result materially, the distance from the center being 15 cm. The moments of inertia were calculated by dividing the magnet into two parts, an inner core and an outer shell extending beyond the core at both ends. On the other hand it is to be noticed that the ratios $\frac{M_{14}-M_{99.5}}{M_{14}}$ differ by less than one part in 300. In this ratio the moment of inertia of the magnet is eliminated. I think on the whole that the accuracy of the work is fairly well shown.

IV. DISCUSSION OF RESULTS.

The result of the experiment may be stated as follows: If a magnet be heated after it has been brought into the permanent state, the proportional loss in distribution is greatest at the ends and least in the middle. A glance at the table on pages 282–83, or at the curves on plate XI, will show this. The same fact may be stated in other words as follows: The proportional change in the number of lines of induction passing through a cross-section of the magnet is greater, the nearer the section is to the end, as is shown by column seven in the table on page 282–83. This

is different from the result obtained by Poloni, who found the proportional change sensibly constant throughout the magnet. It could not be expected that the small difference noticed here could be detected by his method which consisted in measuring two large quantities and subtracting them in order to obtain a small difference. In the method employed in this research the quantities measured differed but little in size from the quantities desired, and much greater accuracy is easily obtained.

I would suggest the following explanation: Prof. Ewing has recently made an important addition to Weber's theory of magnetism. He says the forces which hold the little molecular magnets in position are largely the mutual attractions and repulsions of these molecular magnets themselves. In applying Ewing's theory to the case in hand, let us consider a row of magnetic molecules A B C, etc.

A B C H I J K L

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J is held in position by the action of H I, etc., on the one side and K L. etc., on the other, while A has only B C, etc., to act upon it. It is evident that the force holding J in position is greater than that acting on A. Suppose the bar of which this line of molecules is a part is heated. If in this process the energy of vibration of A and J receive equal increments, it is evident that the increase of amplitude of A will be greater than that of B. Now the magnetic moment contributed by each molecule is the moment of the molecule resolved along the direction of magnetization of the bar. The moment contributed by A would suffer a larger proportional loss than that contributed by J, and so the loss would be greatest at the ends.

There are other facts pointing in this direction, e. g., when a magnet is heated before it has reached the permanent state, Kupffer found, as already stated, that the proportional permanent loss was greatest at the ends. In some rough tests I have made on this point, heating the bar almost to redness, I have found the proportional loss at the ends nearly twice as great as at the center of the bar. This would naturally follow from the supposition made, for the force holding the end molecules in position being less, they are more easily set in such violent vibration as to swing out of one position of equilibrium into another.

I am tempted to add a single remark on another part of the investigation. In every case tried so far, the area of the cycle of magnetization (the largest magnetizing force being the same for all temperatures) is always smaller for the higher temperature. I have only experimented

on soft steel. If the same thing is true for iron and is as marked in degree, I should expect alternate current transformers to work more efficiently at high than at low temperatures. I understand that some efficiency tests point in this direction.

MADISON, WIS., December 28th, 1891.

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EARLY LUTHERAN IMMIGRATION TO WISCONSIN.*

By KATE A. EVEREST.

The first immigration of Germans to Wisconsin in large numbers was that of the so-called Old Lutherans of Pomerania and Brandenburg, who came between 1839 and 1845, as a result of the attempt by King Frederick William IV., of Prussia, to unite the Lutheran and Reformed faiths.

My purpose is to sketch the history of that movement with the emigration that followed and the forming of several German settlements in this state.

Philip Schaff divides the history of the Lutheran church into five periods. The first reaches from the Reformation to 1580, the date of the adoption of the Book of Concord; the second from 1580 to 1700, when the doctrinal system was defined in opposition to Romanism, Calvinism and the milder forms of Lutheranism; the third period reaches from 1700 to the middle of the eighteenth century, and is the time when Pietism was exercising its moderating influence; fourth, the period of Rationalism, which reached the higher circles, the clergy, and the universities, and created a revolution in theology; fifth, the period of the revival of evangelical theology and religion at the third centennial of the celebration of the Reformation in 1817.†

From Reformation times there had been attempts to reconcile the followers of Luther with those of Melancthon and Zwingli, but the year 1580 marks their failure. In that year the Book of Concord was adopted which strictly defined the Lutheran faith in distinction from both Calvinism and the milder forms of Lutherism represented by Melancthon.‡

The controversy had been carried on hotly by the followers of each reformer. At his death, Melancthon said, "For two reasons I desire to to leave this life: first, that I may enjoy the sight which I long for of the son of God and of the church in Heaven; next, that I may be free from the monstrous and implacable hatred of the theologians." ‖

* For information in regard to the Wisconsin communities, I am indebted to the pastors of the churches: Rev. Gram, Rev. E. Pankou, Rev. R. Grabau, Rev. A. W. Keibel, of Wisconsin, and Rev. Philip von Rohr, of Minnesota, also to Dr. Falge, Mr. Blumenfeld and others who have generously given me the information at their disposal.—K. A. Everest.

† Schaff-Herzog Encyclopedia of Religious Knowledge, article. "Lutheranism."

‡ Brockhaus Conversations--Lexicon. Vol. XI, article 'Union.'

‖ Gardiner's "Thirty Years War." p. 13.

The basis of the Lutheran doctrine was the "unaltered* Augsburg confession," the Smalcald article, and Luther's catechisms.

By the Peace of Augsburg (1555), the only Protestant faith recognized in Germany was the Lutheran and that the unaltered Augsburg confession, but in the Peace of Westphalia (1648), both Lutheranism and Calvinism were given a legal standing.

At the beginning of the Thirty Years War it is estimated that between seventy and ninety per cent. of the population of Germany were Protestant and by far the larger part of that number were Lutherans. The seat of Lutheranism was northern Germany, while in the south the German princes had adopted Calvinism. The Reformed faith or Calvinism had taken root in Germany partly from Switzerland, the home of Zwingli, and partly through the teachings of Melancthon, but it never gained that hardy growth in Germany, says Gardiner, that it had in its native soil. It was the religion of the courts, and according to the principle of the times, it became the religion of the people, (*cujus regio, ejus religio.*)

From 1580 to the close of the seventeenth century the lines between the two Protestant faiths were drawn still more closely, and the first modification of dogmatic principles was effected by the influence of Spener and the Pietists. Doctrine became subordinate to "inner light" and to practical piety. It was like the Methodist revival in England but did not result in secession.†

Meanwhile the thought of union was being revived. Frederick I. of Prussia called councils of Lutherans and Reformed theologians at Berlin for the sake of obliterating differences, and in 1737, Frederick William I. sought to unify church usages by abolishing certain forms. But the times were doing more. Rationalism was at work modifying creeds, so that at the end of the eighteenth and beginning of the nineteenth century the Lutheran church had but few representatives.‡ The old hatred seemed strange, even incomprehensible to the new race. Rationalism was above dogmatic strife and Pietism regarded the eternal love as the essence of Christianity. Hence the idea naturally arose that Protestantism might well return to its early unity. Of this idea Schleiermacher was the spokesman and Frederick William III. its propagator, though they differed materially as to the manner in which it was to be carried out.

The beginning of this century was rich with new national life for Germany. Romanticism and the War of Liberation gave rise to a revival of the past. It was a time of peculiar activity and awakening, which called out German patriotism and above all new political aspirations.

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* The Augsburg confession was edited and altered by Melancthon; hence two forms: the *invariata editio* and *variata editio.*

† Brockhaus, XVI, p. 37.

‡ Brockhaus, XI, p. 269.

. Treitschke, Staaten-Geschichte der Neuesten Zeit. II, p. 239.

By all the leaders in this movement a constitution with popular representation was demanded. The idea that the people should participate in government and legislation underlay every attempt at reform. Even in religious matters the same right was recognized. Thus as early as 1813 great importance was attached to the necessity of a free church constitution. The great representative of this idea was Schleiermacher. For this he wrote and worked unceasingly, believing that in this way only could the union be brought about,* but the spirit of absolutism at the Prussian court which was unfavorable to political constitutions, was not less so to a free church constitution.

The year 1817 marks the beginning of a new epoch in religious matters. In that year Claus Harnes published his ninety-five theses against rationalistic apostasy and in the same year at the three hundredth anniversary of the Reformation, King Frederick William III., of Prussia, proclaimed the union of the Reformed and Lutheran churches. The great point of difference between the two creeds lay in the doctrine of the Lord's Supper; the Lutherans taught the real presence of Christ's body "in," "with," and "under" the bread and wine of the sacrament; the Calvinists made these symbolic of the real spiritual presence to believers only. Other points of difference related to the doctrine of predestination which Luther had not taught in any strict sense; but the Reformed church laid great emphasis on moral character, and for that reason was more inclined to the idea of unity than the Lutherans who emphasized doctrinal points.

To the king who was of the Reformed faith the union seemed most simple. "According to my opinion," he had said, "the communion strife is only an unfruitful theological subtlety, of no account in comparison with the fundamental faith of the Scriptures."† The fact that he was outside of the church to which the great majority of his people belonged, was a source of great regret to him. Possessed of a deeply religious nature and for some time under pietistic influences, the union had been one of his dearest objects. Though the act may have been praiseworthy, and was performed by the king in the profound belief that he was called to do that work, yet his unfortunate belief in the sacred prerogative of kings which led him to carry out the reform in a thoroughly absolute manner, was destined to call forth an opposition which ended in the partial failure of the attempt. The union was proclaimed without the consent of the churches, and in 1822, a new agende was drawn up by Bishop Eylert and the court theologians, and in 1830, was rigidly enforced. Schleiermacher, the upholder and defender of the Union, was strongly opposed to the agende, partly on account of its source, namely the royal

*Weber's Weltgeschichte, vol. XIV, p. 900. Brockhaus, articles "Union" and "Schleirmacher."

† Treitschke II, p. 240.

will instead of the free choice of the church, partly on account of its contents, on the ground that they were antiquated and reactionary.

"The Union rested not simply upon a weakening of the opposing Evangelical doctrines," says Weber. "but upon positive dogmatic principles."* It was ostensibly a liberal union leaving the interpretation of disputed points to the conscience of the individual while the Bible only was recognized as the ground of faith and life.

While the movement had many warm supporters and was imitated by other German courts, namely, by Baden, Nassau and Rheinpfälz, yet it was not heartily supported by the rationalistic element, and on the other hand, aroused a new Lutheran consciousness. It was taken as an attempt to root out Lutheranism which the revival of Germany's great past was more likely to restore. This was especially the case in those parts of Prussia where Lutheranism existed almost unmixed, where, then, there was no sympathy with Reformed doctrines and the union was not felt as a practical necessity. This was the case in North Germany — Saxony, Mecklenburg and in Pomerania. "It seemed," says Treitschke, "like an uprising of Reason against Revelation."†

For some years the opposition was confined to literary polemics,‡ but in 1830 when the new agende was enforced by cabinet orders, Prof. Scheibel of Breslau founded a separate society of two or three hundred families, and being refused permission to worship according to the old agende, Scheibel left the country. Many Silesian pastors followed his example and resistance spread rapidly to Erfurt, Magdeburg and different parts of Pomerania. At Erfurt the leader of the movement and afterwards of the emigration to America was Rev. Johannes A. A. Grabau, pastor of the Evangelical church. In spite of an early education under the influences of a pastor of the United faith, Grabau seems to have kept his preference for the Lutheran church. Finally, in 1836, he reached the conclusion that the Union was contrary to the Scriptures and declared publicly that he could no longer use the new agende with good conscience. Being questioned by the counsellor of the Consistory, he replied that the new form in the administration of the Lord's Supper did not express the belief of the Lutheran church, and that their faith was curtailed and weakened in the new spirit of the times. His society agreed with him and when he was suspended from his office and a new pastor was put in charge, they followed him to his house where services were held. This, too, was forbidden, but they decided "to obey God rather than men." The separate society grew until it reached a membership of nearly 400. Meanwhile, at Magdeburg, another small body of Lutherans had separated from the Union church and were holding services at the home of a captain of the guards, Henry von Rohr. The movement was

* Weber 14, p. 900.

† Treitschke, Vol. II, p. 243.

‡ Schaff-Herzog II, 1376.

spreading in Pomerania and many pastors and laymen were being persecuted. In 1837, Grabau was imprisoned and, at that time, there were said to be twenty pastors in prison or banished.* Laymen who refused to send their children to the United schools, or who availed themselves of the administration of Luthern pastors in baptism or marriage ceremonies, but especially those who refused to pay the taxes required for the support of a pastor of the United faith were imprisoned, fined or otherwise punished.

At length Capt. von Rohr who had been deprived of his position as captain of the guards, for his refusal to conform, assisted Grabau to escape from prison where, it was claimed, he was illegally detained. They reached Seehof, on the cost of Pomerania in safety. Previous to this time, frequent calls had come to Grabau from the Pomeranian churches which had been deprived of their pastors, and he now visited and conducted services in the different societies. Already the question of emigration had been talked of here and letters were received from friends in Ohio. Grabau advised them to wait until it was definitely settled whether the Lutheran faith would be tolerated. Accordingly, letters were sent to the government asking, in case it should not be tolerated, for permission to emigrate. To the first question, the answer was "The Lutheran church is within the United church and outside of it, the King will tolerate no Lutheran church in this land."† Permission was given to emigrate, in case they proved to the satisfaction of the government that they had a pastor, but not otherwise. In consequence of this, many societies in Pomerania and the one at Magdeburg placed themselves in communication with Grabau, asking him to become their pastor. Grabau, meanwhile, had been imprisoned a second time, but he received permisssion to emigrate on strict conditions, namely, that he go directly to Hamburg where they were to embark, accompanied by police officers, lest he hold services on the way.

This was in the spring of 1839 and with Magdeburg as a center, a large emigration was arranged for that year. Capt. von Rohr was chosen to engage passage for them and to go in advance to America and choose places for settlement. He chose Buffalo N. Y., and Milwaukee. Just why he selected Wisconsin, it is impossible to say, but after travelling through New York, Ohio, Illinois and Wisconsin, in order to find the best possible location for a settlement, Wisconsin and New York seemed the most favorable. It is thought that the climate which resembles that of North Germany was one inducement. Another was the prospect of obtaining finely wooded lands, always highly prized by the Germans, at low prices. Capt. von Rohr was very fond of the hunt and the west doubtless attracted him strongly.‡ The position of Wisconsin too, as to the routes of

* Lebenslauf des Ehrwurdigen J. A. A. Grabau von John A. Grabau (son). p. 26.

† Life of Grabau. p. 35.

‡ Letter from Rev. Philip von Rohr (his son). Winona, Minn.

travel through the Great Lakes must have been another favorable consideration. Land was plenty and cheap in Wisconsin, and land offices had been established within a few years in Milwaukee, Mineral Point and Green Bay.

To defray the expenses of the journey, a common treasury was formed to which the wealthier members contributed part of their means to assist the poor to accompany them. Directors were appointed for each company, to take charge of the money and distribute it according to the needs of the poorer people.

Passage was engaged for one thousand people in five American sail vessels. Rev. E. F. L. Krause, a pastor from Silesia with his society accompanied them. They emigrated in the latter part of July and reached Buffalo, October 5th. Capt. von Rohr had met them in New York and told them of the places he had chosen and their advantages. Accordingly about one half settled in and near Buffalo while the remainder came to Wisconsin with Capt. von Rohr.

These were chiefly Pomeranians. It is doubtless this body of immigrants that is mentioned in Mr. Buck's Pioneer History of Milwaukee. "The year 1839," he says, "brought the first installment of immigrants from Germany and Norway. The effect of their arrival with their gold and silver wherewith to purchase land was electric . . . . . Whereas Milwaukee had been under financial depression before, now all doubts about the future were dissipated." Again he says: "The first German colony arrived in 1839. It consisted of about eight hundred men, women and children [the number is probably exaggerated]. They brought with them the necessary housekeeping utensils and encamped on the lake shore south of Huron street. The men went about in a business way, examining the government plats in the land office, and having ascertained by all means in their power where lands well timbered and watered could be purchased, they entered lands bounding on the Milwaukee river, between Milwaukee and Washington (later Ozaukee) counties. A small number remained in the village [probably Milwaukee is meant], but the most of them employed themselves without delay in clearing and cultivating lands. The men immediately declared their intention to become American citizens, every man signing his name to his petition, to the number of seventy in one day."*

The majority of the immigrants, over three hundred people, and probably those still possessing some means, went to Mequon and there formed the Freistadt colony, a name chosen, no doubt, to commemorate their new freedom; some settled in Cedarburg also, while a few remained in Milwaukee.†

These settlers were from Pomerania, chiefly from the district of Stettin and from Kamin an Greifenberg and the neighboring country.

* Buck's Pioneer History of Milwaukee, p. 181; and an address by Judge Miller, p. 265.

† Koss "Milwaukee," p. 103. "In der Neuen Heimath." Eickhoff, 372.

Farming and stock raising are the chief industries of this country and the greater part of the land, about 60 per cent.,* is held by large land owners. Stettin is said to be the center of one of the best farming communities in Pomerania.† The Wisconsin settlers were chiefly farm-laborers and handicrafts men, and, accordingly, well adapted to pioneer life. They bought nearly all of the western half of the town of Mequon, where they built log houses and improved the land. Capt. Von Rohr had come with them, and during the first year he conducted their services until the arrival of Rev. Krause from Buffalo, who was their first pastor; immediately on his arrival a log church was built on section 19. In the Milwaukee Society services were held in a house built by a fisherman on land given him by Byron Kilbourn, near Chestnut street. It was a very solid structure, built in true German style of panel work and clay filling. They had no pastor, but the teacher Luck held services, while Rev. Krause came occasionally from Freistadt.‡

In 1843 another large immigation followed from Pomerania, from the neighborhood of Stettin and the cities of Kolberg, Treptow and Kamin, on the Baltic, and also from Brandenburg, from the country lying between Küstrin and Wrietzen on the Oder. Rev. Kindermann acted as their leader. He had been directed to the Pomeranian churches by Rev. Grabau during the earlier period of the persecution.§ Others continued to come until 1845. It was the reports of the earlier emigrants, who were their friends and acquaintances, that led them to Wisconsin.

The cause of this emigration also was religious persecution, which had not yet ceased, though it was abating.‖ But there were other causes as well. Differences had sprung up in the Lutheran church in Germany over the question of church government. The decrees of the synod were that in disputed questions of doctrine, the majority of votes should decide. Against this one party protested and claimed that the only ultimate authority was the Scriptures. To this party, which was the weaker, Rev. Kindermann belonged. To avoid unpleasantness, therefore, they decided to emigrate with those of like mind.

This company, too, had formed a common treasury to which the wealthier members contributed from 15 to 20 per cent. of their means to assist the poor, both in the passage and in purchasing land. It was expected that the money would be returned with interest, but in many cases this has not been done and the creditors have overlooked it.

Of this second body of immigrants, altogether about four hundred families, some remained in Milwaukee and joined the first comers in the

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* This includes the estates containing 600 morgen (acres) and more.

† Brockhaus Conversations-Lexicon, article, "Pommern." *Also* Schönberg's Handbuch der Politischen Oekonomie. Auflage 2, p. 962.

‡ Koss, Milwaukee, p. 103.

§ Life of Grabau, p. 29.

‖ Separate worship was allowed by King William IV, in 1846.

neighborhood of Chestnut street, but the majority went to the farms. Kirchhayn, Washington county, and Lebanon, Dodge county, were chosen for settlement. Lebanon was chosen by the advice of their countrymen, J. Grünhagen, one of the earlier immigrants to Milwaukee, probably for its situation on the Rock River. Seventy-eight families settled here in the years 1843 and 1844. These were the people from Stettin and Brandenburg, while those from the Baltic lands settled at Kirchhayn.

Rev. Kinderman became the pastor of the Kirchhayn people, while at times he held services for the Lebanon community. For a year or two the settlers in Washington county suffered great privations; their land was heavily wooded and it took time to make it productive. Lebanon was more open and easier to cultivate. "Within fifteen years," says Mr. Blumenfeld, of Watertown, "the country became a garden, and to-day it surpasses most towns in its high state of cultivation." Both the communities by their industry and thrift, have been successful. There has been a marvelous change in the condition of these people from that of poor farm laborers, in most cases, to that of independent proprietors, almost all well-to-do farmers.

Between 1850 and 1860, a number of the early setlers went from Freistadt, Cedarburg and Kirchhayn, to Sherman, Sheboygan county, and Cooperstown, Manitowoc county. Land was cheap and plenty in the northern counties and there again they formed prosperous settlements.

The large Pomeranian and North German element in Wisconsin is undoubtedly due in great measure to the early emigration of the Old Lutherans to the state. Through their reports to friends and relatives in the Fatherland, many have since followed them and either joined the original communities or spread out into adjoining towns and counties. Moreover, in 1853, Capt. von Rohr and Rev. Grabau made an extended tour through Germany, especially through North Germany, and by their conversations and reports about the success of their countrymen in Wisconsin caused the majority of the Lutherans to settle in this state. Emigration from the northern countries had scarcely begun at that period but since 1870, Pomerania, Prussia and the adjoining countries have furnished the greater part of the German emigration, of which Wisconsin has received a large share.

But these early settlers were not only the first body of German immigrants to Wisconsin; they were also the beginning of the Lutheran church in the state.

Freed from state support and government restraint the Lutheran church has grown marvelously in this country. One indication of its growth is its large membership;* another indication is the variety of creeds that have developed, shown by the large number of synods of

* According to Prof. Ernst there are 200,000 Lutherans in Wisconsin.

which there are five in Wisconsin representing differences of creed more or less fundamental. In these original communities questions of church government and religious belief caused divisions, through which the Missouri Synod and others were able to establish separate churches.

Between 1840 and 1850 the two synods of Buffalo and Missouri were formed; the one by Rev. Grabau, the other by ministers from Saxony. Soon a controversy arose between them on the question of the calling and ordination of the clergy and the relation of the minister to his society. Rev. Grabau held that a minister must be called according to the old church ordinances, and that the society must obey their minister in all things not contrary to the word of God, while the Missouri Synod held more Congregational views.* In this controversy Rev. Grabau was supported by Rev. Kindermann, Rev. Krause and deputies from Milwaukee who signed themselves "The Lutheran Synod of the church emigrated from Prussia."†

In Milwaukee, meantime, they were still too poor to hire a pastor and Rev. Krause had come from Freistadt every six weeks, but the journey was long and expensive, so he called upon the 150 communicants to pay each three cents a week for twenty weeks to buy him a horse and wagon, but the tax appeared too large to them and they refused his request. The demand was doubtless somewhat arbitrarily imposed, Rev. Krause being a man of the extreme type of clerical dignity. The society was severely rebuked by him, and was finally refused admission to the communion until they recognized their sins and made public confession, but the difficulty only increased and finally a large part of the society withdrew and joined the Missouri Synod, which allowed more self rule. The separated society was supplied with a pastor from Missouri and formed the nucleus of the later Trinity society, the first of the numerous churches in the state belonging to that synod; the remaining element formed what is now the St. Paul's society, in Milwaukee, belonging to the Buffalo Synod.‡

In the Lebanon community a controversy arose in 1847 on the subject of worldly music which caused one party to form an independent organization. Later in the same church the use of the private confessional was discussed, and again in the Milwaukee church. The demand for the general confessional in its place caused the disuse of the private confessional in nearly all the churches after a few years.

There questions indicate an activity in the societies, partly the result of new conditions and the union of people from different communities in Germany, and partly the result of their recent experiences. In the

* Wolf's Hist. of the Lutheran Church in America, p. 413.

†"Hirtenbrief des Herrn Pastors Grabau zu Buffalo vom Yahre, 1840."

‡Hist. of Milwaukee, by Frank A. Flower, p. 924; and Koss,' Milwaukee, p. 137 seq.

Bericht des Nordlichen Districkts der deutschen Evangel. Luth. Sy ode. von Mo., Ohio, u. a. Staaten 1855 and 1858

Lebanon community, it is said that each family owns its set of Luther's works and is familiar with theological questions. It is not strange then that there are six churches there with three pastors, of whom one is independent, another belongs to the Iowa Synod, and another to the Missouri Synod.

In Kirchhayn, Cedarburg and Freistadt also, in 1855, we find besides the churches belonging to the Buffalo Synod other societies belonging to the Missouri Synod.* Such divisions are not infrequent as the result of an unusual mental and spiritual activity, as for example Germany itself in Reformation times and England in Puritan times.

While the other synods have increased rapidly in numbers in Wisconsin and other states, the Buffalo Synod has remained comparatively isolated and small, owing to its very conservative character, and its rigid adherence to earlier doctrines. The use of the private confessional is still preserved in its churches, while its doctrines adhere to the old Saxon and Pomeranian church ordinances. The synod has but five churches in the state and these are all the original communities who emigrated between 1839 and 1845. They are Milwaukee (St. Paul's), Cedarburg, Freistadt, Kirchhayn and Sherman. The Cooperstown church, though belonging to the Wisconsin synod, keeps the doctrines and forms of the Buffalo synod.

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* Bericht — 1855.

THE CLAN CENTERS AND CLAN HABITAT OF THE EFFIGY BUILDERS.

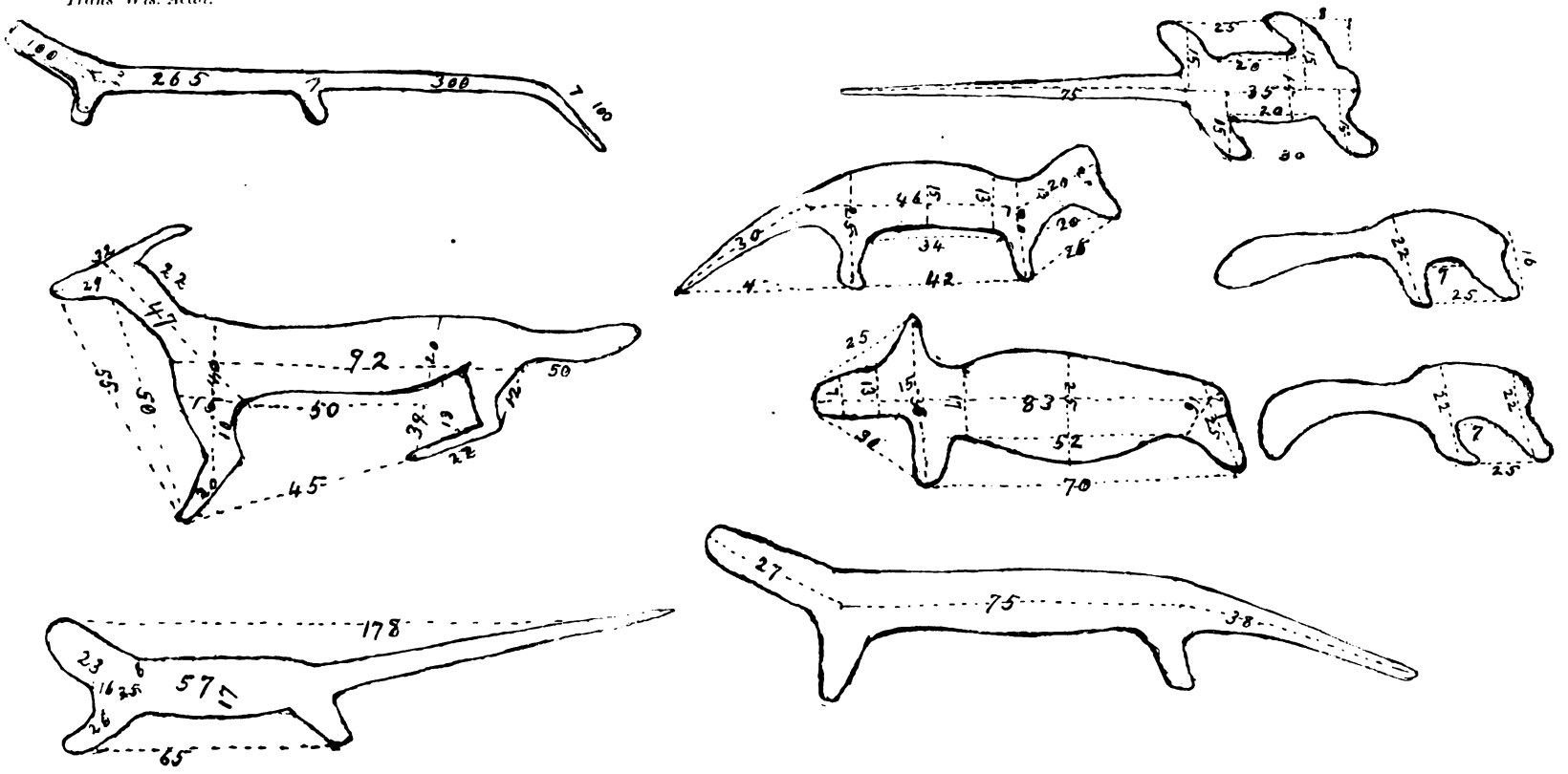
By STEPHEN D. PEET, Ph. D.

The animal effigies of Wisconsin are very interesting specimens of the handiwork of a people who have passed away. Who this people were, is at present unknown. They were, however, remarkable for one thing—their skill in imitating animal figures and especially in molding massive imitative forms out of earth and raising bas-reliefs above the surface so that they could easily be seen and recognized. Nowhere on the face of the earth are there so many of these effigies as here, and nowhere else can we learn as much about the effigy builders. There are, to be sure, a few effigies in the state of Ohio which, like these in Wisconsin, are molded from the soil. They are as follows: The Great Serpent in Adams county, the Alligator mound, and the Bird mound in Licking county, and the animal effigy in Scioto county, near the mouth of the Scioto river. The writer has discovered also a massive serpent effigy near Quincy, Illinois, and other gentlemen have discovered turtle and animal effigies, both in northern Illinois and eastern Iowa, though these probably belonged to the same system with the effigies of Wisconsin, stray specimens which were built beyond the borders of the state. Other than these, no effigies made of earth have been discovered anywhere on the continent. There are, to be sure, effigies made of stone in various parts of the country, as follows: Two in the shape of birds, discovered in Georgia and described by Col. C. C. Jones, who is one of the most skillful archæologists. Several in the shape of serpents, turtles, buffaloes and human form in Iowa, described by Prof. John Todd and Mr. T. H. Lewis. The figures of birds, turtles and nondescript creatures may be frequently seen inscribed upon rocks. Marquette, the missionary, saw one such near Alton, Ill. Jonathan Carver saw others in the caves in Minnesota. Rev. Edward Brown described those in West Salem, Wisconsin. Mr. T. H. Lewis has made a study of those found in the caves of Iowa and Minnesota. It may be said, however, that the effigies made from earth, notwithstanding the havoc made with them by the relic hunter and the farmer, have proved about as enduring as those made from stone, and no more liable to be marred and destroyed than are the inscriptions in the caves. This makes the responsibility of the citizens

of the state all the greater. The effigies of Ohio are some of them to be preserved by especial enactment. The serpent effigy has been purchased and the ground about it laid out in a public park. No public movement has, however, taken place in Wisconsin, which looks toward the preservation of these most interesting monuments. They are rapidly disappearing. At the present rate of destruction, it will not be long before they will all be gone beyond recovery. When an effigy has been destroyed it is impossible to restore it. If it is reconstructed it has a modern look to it and lacks the peculiar air and grace which a native hand alone could give. The touch of the white man's hand is different from that of the mound-builder. It would be useless for him to attempt to reconstruct these animal forms.

Many things have been impressed upon us from the study of these effigies, some of which we have already embodied in the work on Emblematic Mounds which was published in 1890. Other things, however, have been brought to light by later explorations and to these we would now call attention:

I. In reference to the imitative skill of the effigy-builders, it is well known that early and rude races had this in a remarkable degree. We need only to go to the cave-dwellers of Europe to be convinced of this. Here we find the mammoth, the reindeer, the horse, and many other animals plainly drawn on pieces of ivory. They are excellent imitations and show that the early races excelled in this. We do not, to be sure, recognize in these the religious feeling which was exercised in erecting effigies on the soil of Wisconsin. There are however inscribed figures on the cylinders which have come down to us from the early historic times, which have more of this religious symbolism embodied in them. We do not know that these figures are totemistic in their design, but they are symbolic at least and are wonderful imitations. Let us take the cylinder that belongs to Sargon, 3300 before Christ. Here we find Izdubar watering the sacred oxen. The oxen have wide-spread, branching horns and small bodies — resembling Texan cattle. The human figures have strange, wild faces and shaggy hair and resemble Scythians but the drawings are excellent, the muscles are plainly seen on the oxen, the expression in the faces is striking, and the water which flows from the vessels is very like water. The effigies of Wisconsin are probably not as old as these figures from the caves of Europe or from the mounds of Chaldea, but they show the same imitative skill. Let me illustrate this: There is an effigy on the east bank of Lake Mendota but two or three miles from the capitol which represents a deer in the attitude of jumping. (See plate XII.) The deer has the head partly thrown back, the rump thrown up, the hind legs drawn toward the body very much as any deer would jump. An instantaneous photograph could not take the attitude better than did these native artists. The effigy comes to its place remarkably well, when the meas-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urements are taken, and the lines drawn according to a scale of inches. The eye is useful in determining the animal intended but the platting brings out the attitude more perfectly. Take another instance: There are two animals north of Buffalo lake, not far from Crooked lake, which resemble squirrels. The platting of these effigies brings out the fact that they are not squirrels at all but raccoons. We find in them both nearly the same measurements, but as the lines come out on paper we find the crooked legs, the small head, the high curved back, the short belly and the curved, bushy tail — all of which are peculiarities of the coon. Near these coons we find a turtle — but a turtle in a most novel attitude, the same attitude which a horse assumes when he "racks," two legs upon one side thrown forward, two on the other side turned back, the whole figure being distorted and twisted as only a turtle can twist. (See plate XII.) On the west side of Green lake, squirrels appear in great numbers; every one of these squirrels has a different attitude, but an attitude perfectly natural to the animal.

II. In reference to the work of identifying the animals in the effigies. A writer in the *Nation* of New York, seems to have doubts in reference to this point. He thinks it is impossible for any one to train his eye to recognize the animals in the figures and insists upon it that the surveyor and the naturalist be summoned before one undertakes to identify the animals or decide as to the intent and hidden significance of the figures. This is an old complaint but one that is too hypercritical to be heeded. We do not deny the value of the surveyor's services and stated in the very introduction to the book that the first discovery of the shape of the effigies, was made by those engaged in the work of surveying the mineral lands. We have also everywhere given credit to the gentlemen who first platted the effigies. We have frequently quoted Dr. Lapham, and have acknowledged our indebtedness to him. We have also used the unpublished notes of Mr. H. M. Canfield, of Baraboo. This gentleman seems to have been correct in all of his observations. We have found from experience that the eye does become trained, so that it takes in large figures, and one may come to recognize the animal intended even before the measurements have been made. This, however, must always be subordinate to the surveying and every observation must be verified by measuring and platting.

The hidden significance of the effigies can not, however, be given by surveying. This comes to the mind only after a long, close study of the effigies in connection with the very locality where they are found. They must be compared with one another and classified. The totem system also of the wild tribes must be studied and then taken as a key into the field and applied to the different groups and collections of groups. We do not say that the totem system as it is now known will solve all the problems, for there are many things which baffle us, notwithstanding

the application of this system. We find ourselves on the borders of an unknown realm, so much lies beyond us that we feel that we have hardly passed the rudiments, still we are sure so far as we have gone. It is possible that the effigies are myth bearers as well as totems, and that we shall need to know the myths before we can fully explain the figures. Picture writing may, also, have been practiced in the effigies, for there are groups of mounds in which the animal figures are so related to one another that it would seem as if there was a pictograph on a large scale,—these, however, are few and perhaps we shall be able to explain them in some other way. There may be other escoteric systems and various sacred mysteries embodied in the effigies. Possibly a transmitted symbolism will yet be discovered. To illustrate: There is a figure of an owl, with its projections above the head, making it resemble the horned owl. The eyes of the owl were not in the head but were under the wings and were composed of two small circular ponds of water. (See fig 1.) This effigy is found near Merrit's Landing. The whole figure taken together makes a symbol which is very common in America. The symbol consists of the eyes and nose of the divinity, and is found in Mexico and Central America as well as in the mound-builders region. The same symbol was found by Schlieman, in Troy.

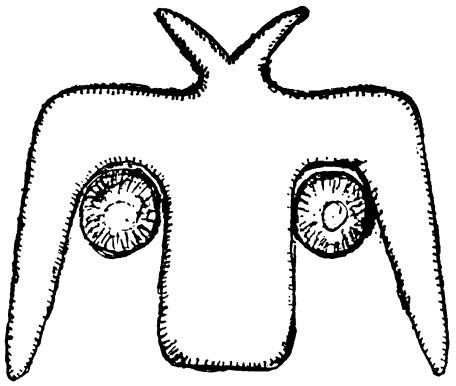


FIG. 1.—Horned Owl near Merrit's Landing.

III. Location of the clans. In the book on the emblematic mounds, we stated that there were various clans whose habitat could be easily bounded; within that habitat all the processes of clan life could be recognized in the effigies. We stated that the turtle clan was located on the Rock river and extended from Lake Koshkonong above Janesville, through Beloit and Rockford to the mouth of the Kishwaukee river; possibly Lake Geneva should be embraced within the bounds of this clan. We located, also, the panther clan on the Fox river, made it to extend from Milwaukee to Racine to the state line, and embrace the

large group of mounds near Big Bend on Fox river, and including another group near Burlington on the same river.

The wolf clan we located on the Milwaukee river. The raccoon clan on the Sheboygan river. This fixed the map of the southeast part of the state. The southwest part of the state was, however, uncertain. Since the book was published we have visited this part of the state and have passed up the Wisconsin river a second or third time, filling in the links, and are now prepared to give the chain of clans which stretched from the mouth of the Wisconsin river, up through to the Dells, and from the Dells across to the Fox river and from the Fox down to its mouth. This is the old historic waterway, but it was occupied in prehistoric times. We begin in the southwest part of the state. Our first point is at Potosi, an old mining town. Here we identified two serpent effigies and a panther effigy. The mounds, however, here are mainly long mounds and stretch in lines along the summits of the narrow bluffs—very few effigies among them. (See fig. 2.) Cassville was the next point. Here we discovered on the estate which formerly belonged to Gov. Dewey, and now belongs to Gen. Newberry, of Chicago, a large number of long mounds. There is a large group of burial mounds on the bottom land opposite the picturesque ruins of Gov. Dewey's house.

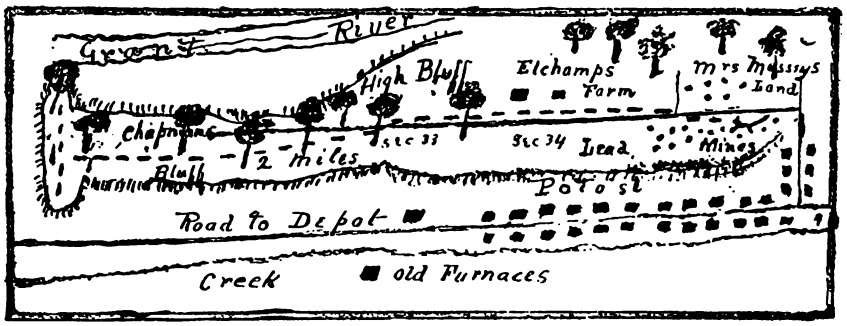


FIG. 2.—Line of Mounds near Potosi.

Passing up the Mississippi river, we come to the mouth of the Wisconsin river. Here we find the bear or buffalo upon one side and the swallow upon the other. Passing up the Wisconsin we come to Boscobel. Here through the politeness of Dr. Armstrong, we were able to visit several groups both west and east of the village and to fix the limit of the swallow clan. The group which marks the boundary of this clan is situated near Port Andrews, and is quite a remarkable group. It consists of a line of swallows over a mile long. (See fig. 3.) The swallows are on the slope of the hill near the bank of the river and underneath the rocky cliff which is here very high. The road runs along the edge of the cliff, and overlooks the land where the effigies are. They can be

plainly seen from the road and are very interesting and beautiful though they are fast disappearing under the plow. There is one swallow here of which we shall speak hereafter. It is at the end of the line of swallows but is placed by itself on a knoll, and so surrounded by long mounds as to be protected on three sides, constituting a sort of enclosure by itself. East of this, in the neighborhood of Muscoda we find the eagle to be the common emblem.

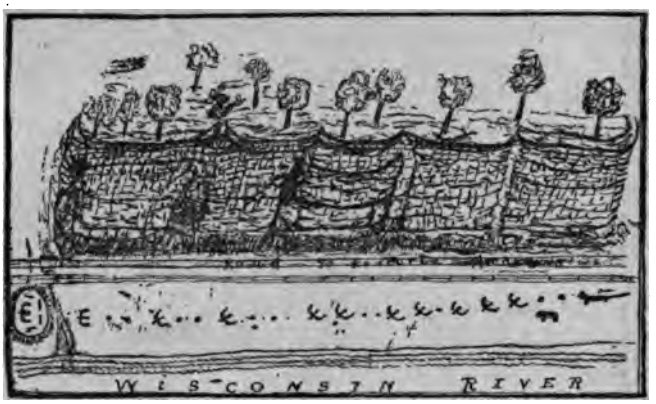


FIG. 3.—Line of Swallow Effigies near Port Andrews.

The eagle clan appears to have been a large clan. It extended from near Port Andrews, up through all the towns on the Wisconsin river and as far east as Sauk City and even extended over the water-shed, and left its totem on the banks of the four lakes at Madison. Mr. S. Taylor was the first to recognize the eagle, but he said nothing about the eagle clan and did not follow up the subject in this way. In fact all the early Archæologists were successful in their work of identifying particular birds and animals, but did not undertake to trace the clan emblems or to study the totem system. The eagle effigy, discovered by Mr. S. Taylor, at Black Earth, marks the western extremity of this clan. The eagles which, in company with Prof. F. W. Putnam, we discovered at the Dells, may have marked the eastern extremity, though the center of the clan habitat proper was in the vicinity of Eagle township. We notice that there is a difference in attitude of the eagles. At Muscoda there is a bird effigy which is about 1,000 feet in length with the wings straight out. We also found about twenty eagles with their wings partly folded in the spread eagle attitude. At the Dells of the Wisconsin and near Sauk City, the eagles have their wings in a straight line, exactly as they are on the asylum grounds north of Madison. At Honey creek there are two eagles near a game drive, and near the game drive two elks with a foe watching the elks, but in this same locality we discovered several swallows, showing that the swallow clan came into the territory of the

eagle clan and placed their clan effigy on the same ground. The Eagles seem to have been great hunters, for there are a great many game drives in their territory — the elk and the moose being very common. Next to the eagles were the mink — the same clan that we have referred to before. This clan seemed to have had its center in the neighborhood of Baraboo, but it extended south across Sauk Prairie to Honey creek, east to the four lake region, north to the neighborhood of Portage and northeast to Buffalo lake. There is a group of effigies near the stone quarry two miles west of Madison, in which there is a large elk, a mink, and an eagle. There is another group near Merrill's Springs, in which there are two buffalos and an eagle, but no mink, and half a mile east, two eagles, a wild goose, a wolf and several animal effigies. The mink is not common in the four lake region, but is very numerous about Baraboo. The raccoon is another clan. This was located northwest of the mink clan — in Adams county and Juneau county. The raccoon is a very interesting effigy. It is difficult to measure and to plat, but when it is platted, comes out very beautifully. The wonder is that the effigy builders could have made it so correct. They were much better imitators than the ordinary white man. The individual who has made the work a study sees more skillful molding of animal forms than he is able to exercise in delineating them and is led to go beyond the critics, especially if they are critics who have never seen these imitative forms.

The clan east of the mink was that of the squirrel. Their habitat was very extensive. It reached from Buffalo lake across Green lake to Winnebago lake, and occasionally visited Horicon lake, even to the headwaters of Milwaukee river.

IV. The manner in which the clans marked their boundaries is another point. The effigy builders were evidently hunters, but they were hunters who seem to have carried this totem system to a great length. We find clan totems present everywhere and are able to recognize the clans by the effigies. A preponderance of one particular animal or bird over all others will be so great in one region, that it becomes a certainty that this was the clan emblem. We can fix even the habitat of the clan, by this means. Having entered into the region, we first ascertain the preponderating effigy, then follow this to the limits, until we find a change to some other. Within the bounds the clan totem appears not only in the villages and centers but near the game drives, and near temporary encampments. We ascertain by this means all about the clan. 2. The clan totem is not often carried beyond the habitat but appears near the boundaries of other clans. In such cases the effigies which embody the totem will be much larger than nearer the clan center. There may have arisen at times disputes as to the hunting grounds. This would lead the clan which claimed the hunting ground to make its totem specially conspicuous. 3. We find also, that the emblems which are

placed on the borders between two clan habitats are not only very large, but they seem to be associated with all the animals which would naturally be hunted; the moose, elk, buffalo, bear are grouped together, and the clan totem placed in the same region.

We now take up the illustration of these points. Let us begin at Merritt's Landing. (See fig. 4.) Here there are two or three very large mink effigies,—one of them 700 feet long. It is so long and so level that the farmer who owns the land has placed his gateway at the head of the mink and drives to his field on the body of the mink, the roadway being open where the effigy is, but a second growth of timber comes to the very edge of the mink on either side. This mink is nearly as long as the whole drove of animals, the group on the edge of the lake being 1,000 feet and this 700 feet long. Another mink near by measures 450 feet.

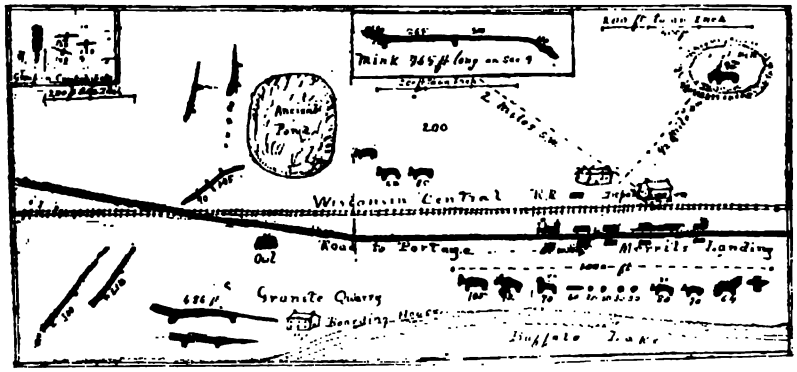


FIG. 4.—Group of Effigies at Merritt's Landing.

These effigies mark the border of the habitat of the mink clan. This clan extended from Sauk Prairie, through Baraboo across the portage of the Wisconsin and Fox rivers to the North side of Buffalo lake. On the south side of the lake about ten miles to the east of the mink clan the habitat of the squirrel clan began. Both clans seem to have had their hunting grounds on this lake. The elk, buffalo, moose, were the animals which they hunted. There are many elk effigies on the north side of the lake but the mink effigy is associated with them, mink effigies being found, also, west of Buffalo lake, near the head waters of the Fox river. Squirrel effigies extend across to Puckaway lake on the north side but do not extend west of Buffalo lake. The squirrel clan also hunted the elk. There is a group of squirrel effigies near Montello but there is an elk effigy surrounded by squirrels, and everything in the group indicates that it was the hunting ground of the squirrels.

There is one contrivance which the squirrel clan adopted that is worthy of notice here. They made two squirrels on a large scale, twisted

the tails of the squirrels around over the back, very much as it is twisted in the squirrel effigy on the asylum grounds opposite Madison, but between the tail and the body of each squirrel, they dug a large pit in the sandy soil and so made a trap for the animals which they would drive from the forests towards the lake.

It is probable that they placed timber or brush, palisades or fences around these traps but the squirrel effigies and the pits are all that are left. The mink clan placed a moose on the highest hill that they could find and from the top of this massive effigy could watch the squirrel clan chase their game; for the two groups are not so far apart but that on a clear day, they might recognize their presence or at least they could exchange signals with one another. We are convinced that the clans were friendly for these signal stations are scattered all over the state; but the border lands between the clans may have been common property.

V. We now turn to the clan centers. The question which arises here is, whether there were any clan centers which can be recognized. It is well known that every clan has its central organization, its village site, its council house, its burial place, frequently its place of sacrifice, and its own place of assembly. The hunters did not differ from others in this. They had game drives and frequently encamped away from their villages, but there was among them a clan organization and a clan center. It has been therefore a purpose with us to discover the clan centers. We think we have done this in some cases, but in others are somewhat doubtful. In the book on Emblematic Mounds we have spoken of the villages of the effigy builders, one located at Big Bend, another at Waukesha, both on the Fox river, another at Racine. The village at Racine was situated on the summit of an isolated bluff and was surrounded by conical mounds and panther effigies. There were lookout mounds on adjoining hills and garden beds in the valley below and a large number of burial mounds on a hill opposite the village. The village at Big Bend was surrounded with oblong mounds and panther effigies. Opposite this, on a high bluff, was an altar mound and some two or three miles west was a game drive and another two miles north of the village, both of them abounding with panther effigies. Caches, or pits, for storing corn were numerous near this village. The enclosure at Aztlan may have been a clan village or it may have been a general capital or a place of general assembly for all clans. Mr. W. H. Canfield has located the village of the Mink clan, near Baraboo, and has spoken about the council house. He represents this as a sort of circle or enclosure, which is surrounded by a large number of animals, the mink being the most numerous. If we take this as our clue, we should place the council house of the Turtle clan on the east side of Lake Koshkonong, for the group here resembles that at Baraboo in many respects.

We discovered at Green lake, a circle or ring of earth in the midst of a large number of effigies, the fox, eagle, wild goose, but the squirrels largely preponderated. This ring was situated not far from the village, the village being near the water, with the squirrels guarding its gateways, but a council house on the hilltop remote from the water. One peculiarity of these so-called council houses, we do not understand. We find around them so many effigies which are different from the clan emblems, a strange mixture of animal forms. In Catlin's Indians is a description of a medicine lodge of the Mandans. The medicine man sits in his lodge and summons all the animals which are the totems of all the tribes. We have the same picture in the effigies. In one place at Lake Koshkonong, we have the eagle, turtle, the fish, pigeon, woodcock, the blue heron, the wolf, the lizzard and many other animals. At West Bend we have the lizzard, the wolf, wild cat, coon, snake, and about a dozen squirrels. At Baraboo we have the elk, buffalo, bear, wolf, eagle, coon, fox, and a large number of mink. At Beloit, the panthers, wolf, bear, pigeon and several turtles. All of these are grouped together in a very remarkable manner. We call these council houses, but we do not understand all of the features that are embodied in the group. This is the point which we confess to be obscure, but think we are on the borders of a constructive, rich field, but do not pretend to have fathomed the subject.

VI. The citadels or sacred enclosures will be considered next. Here we draw a distinction between groups of effigies, in the midst of which are the circles or earth-rings which we call council houses and the long lines of effigies at the end of which are what we call "sacred enclosures," but which Mr. S. Taylor called "citadels." These are lines of long mounds which have no "citadels" or "inclosures" connected with them. These are placed "generally," at the summit of long narrow bluffs, on high land, and were probably used either as screens or hedges or barriers to stop the flight of wild game, to drive them into narrow openings, or as elevated roads for hunters to run upon when they were chasing the game. They are in the most sightly places, and are elevated to a uniform height and run along the summit of the bluff for many miles. There are very few effigies connected with them. They are different from the lines at the end of which are the citadels. The "citadels," so called, are nothing but little clusters of effigies, five or six in number, so arranged that they form a sort of enclosure. In the center of the area, there is always to be seen a mound of some kind, either a high lookout mound, or an effigy. There are many such citadels, at least one to every clan habitat. A good illustration of this is found in the isolated clusters in the Port Andrews group opposite Boscobel. (See fig. 3 and 5) Here the effigy is a swallow—a totem of the clan which lies to the west. It is surrounded by long mounds, and forms an unique cluster. It is at the end of a long line of effigies, all of them swallows. Another example is found near Muscoda. The group is here prom-

inent and forms the top of the principal mound; occupying the center of the enclosure, may be seen at least 100 elevations, which stretch about 400 yards to the westward. The effigies which form the walls to this enclosure are eagles, the eagle being the totem of the clan at Muscoda. A similar cluster has been described by an old settler living near Merritt's Landing, as having formerly existed on a knoll not far from his house. The effigies surrounding the enclosure were mink, their tails extending out long distances, like the spokes of a wheel, their heads toward the center. We have said that the mink was the totem of this region. We would say also that one of the groups of effigies of this place consisted of a long line of elks which stretch along the borders of the lake. The so-called citadel on the top of the hill was not far from the end of this line.

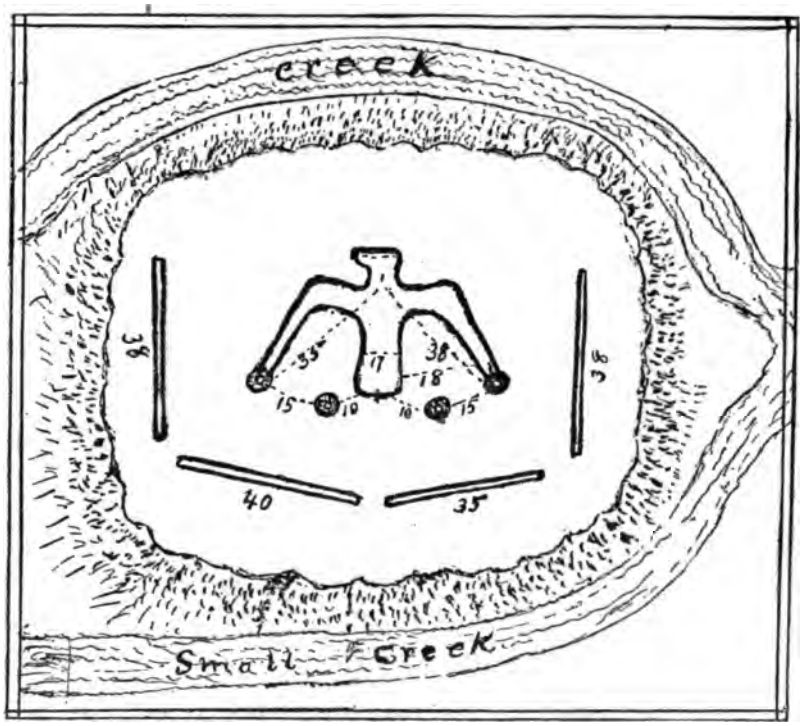


FIG. 5.—Sacred Enclosure near Port Andrews.

Mr. R. C. Taylor discovered a long line of "bear effligies" near the "Blue Mounds" in Dane county. In the line was the man mound. The line was about one and one-half miles in length and contained six effligies of bears, six oblong mounds and one effigy of the human figure and a small circle. There is a group on the south shore of Lake Mendota near Merril's Springs. Here there is a short line of burial mounds with the effigy

of the eagle at one end. At the east end two buffalo effigies, three oblong mounds, arranged around a central lookout or conical mound. This we should hardly call a citadel though it illustrates how the effigies are sometimes clustered or grouped around a central mound.

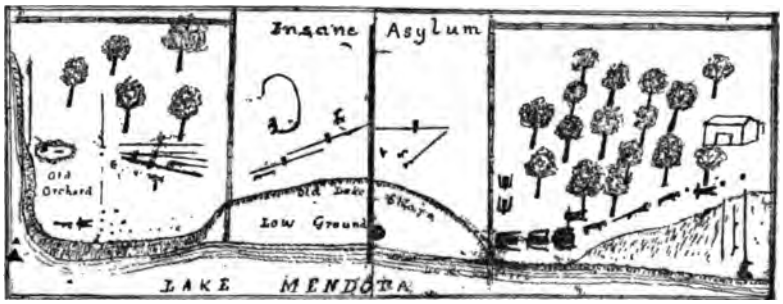


FIG. 6.—Group of Mounds on north shore of Lake Mendota, Madison, Wis.

The group on the north shore of Lake Mendota differs from this and from nearly all other groups which we have visited. (See fig. 6.) Here the effigies are neither in a line with a citadel at the end nor are they grouped around a central circle with the "council house" in the circle but they are arranged in a row with the heads of many of them toward the lake.

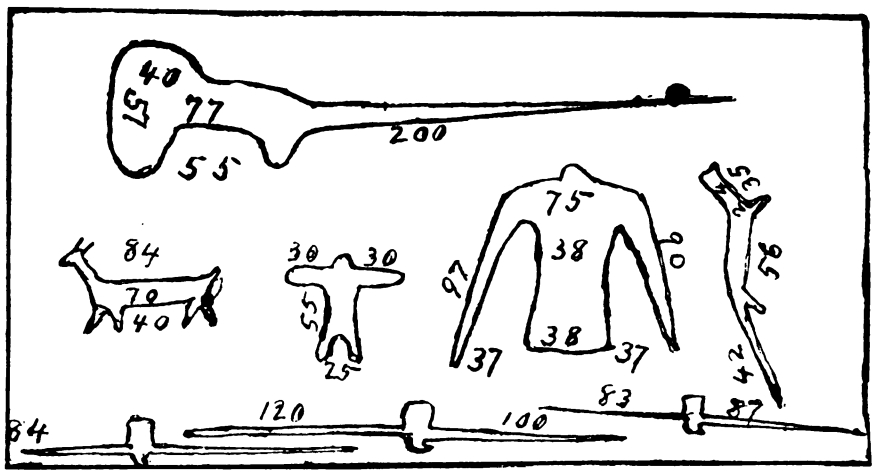


FIG. 7.

There are in this entire group from 40 to 50 mounds — many of them effigies, but no one class of effigies preponderating. At one end is a very large animal which we call a panther, next to this is a mink, at the end of the mink, a man mound, near this a buffalo, next the fox, then the bear, and another man mound and three or four pigeons of gigantic size. (See fig. 7.) In the front of the asylum three eagles, a wolf, a bear, a

fox and a squirrel. West of the asylum we find three long mounds with an effigy in the midst on the side hill — on the top of the hill an animal with a very long tail, possibly a squirrel, another with a short bushy tail, perhaps a raccoon, another man mound, and a large cluster of burial mounds, one of which contained an altar. These effigies do not bear the right proportion to one another, for the panther is some two or three times larger than the buffalo and the pigeon is even larger than the panthers. The fox is very slender but the two man mounds are even smaller than the fox; the deer is very small, not an eighth as large as the eagle, but the squirrel has a tail 300 feet long, which is really the longest tail we have anywhere seen.

Our explanation of these two classes of works is that one (the citadel) embodied the council houses or assembly places of the clans, the other the houses of the chiefs or clan rulers. This is conjectural but satisfies the demands of the problem better than any other conjecture. We throw it out merely as a suggestion, but would call attention to the different classes of mounds as they are brought before us on this general map. The habitats of the different clans may certainly be ascertained by the totems. We think also that the clan centers can also be ascertained and the different places where clan life embodied itself can be identified. Their villages with their game drives, burial places, sacrificial places, dance grounds, assembly houses, council houses, and the houses of their chiefs, all can be located by the study of the effigies.

THE LIMONENE GROUP OF TERPENES.

By EDWARD KREMERS.

The following historical study was undertaken with the desire to throw some light upon the history of the terpenes. This class of compounds has been of interest to chemists ever since organic chemistry may be regarded as a science. Year after year the material accumulated until by the beginning of the last decade it constituted a special lumber-chamber of chemical literature. The reasons for this disorder are of a varied character. The thought that every volatile oil contained its peculiar terpene, when such was present, for a long time seems to have prevailed in the minds of chemical investigators. Another grave fault is to be found in the fact that one investigator often gave but little or even no attention to the researches of others. This brought about serious confusions in the chemical nomenclature, which in turn gave rise to misunderstandings everywhere. The reason why, even in later years, so little could be done to clear up the subject is to be sought in the fact that for the most terpenes, no characteristic reactions were known. Since at present, at least some systematic knowledge has been acquired, it may not be without interest to look back and see who has identified himself with the problems under consideration, who has aided in their solution and who has retarded the same. In the course of years the amount of material has accumulated to such an extent that a survey of the same is a difficult matter, even for the person who has made a special study of the subject. In fact an understanding of the Limonene group of terpenes became possible only after Prof. Wallach, in 1888, had demonstrated the relations existing between the members of this group.

For the better understanding of the subject the following explanatory remarks may serve as a brief introduction. The limonene group of terpenes consists of three hydrocarbons: the optically active, dextrogyrate and lævogyrate limonene and the optically inactive dipentene. Whether the inactive compound resulting from the mixture of equal parts of the optically active components is identical with dipentene still remains an open question. Suffice it is to say that all crystallizable derivations of such an optically inactive mixture are identical with the corresponding

* These notes are translated from a series of articles published on this subject by the writer in the "Pharmaceutische Rundschau" of 1891 and 1892.

dipentene compounds. The two physical modifications of limonene can add one molecule of hydrogen chloride without loosing their optical activity. The additions of a second molecule, however, renders them optically inactive, they are then no longer limonene, but dipentene compounds. Pinene, the most characteristic hydro-carbon of the turpentine oils, adds one molecule of hydrogen chloride to form the so-called artificial camphor, or pinene, monhydrochloride. Under certain conditions it also will add two molecules of hydrogen chloride and thus be converted into dipentene dihydrochloride. Limonene as well as pinene can be "inverted" into dipentene. This inversion can also take place through terpin hydrate. Limonene, and pinene even more readily, will add three molecules of water to form terpin hydrate. This optically inactive hydrate is no longer either a limonene—or pinene—but a dipentene derivative. As will be shown later these inversions for a long time baffled chemical investigators, and it is but recently that their character is being understood. This knowledge, the outcome of a series of investigations by Prof. Wallach, has at last shed considerable light upon the constitution and isomeric relations of the terpenes.

THE HYDROCARBONS.

SYNONYMS AND HISTORY.

Dextrogyrate Limonene.

Citrêne — J. Dumas,[1] 1833.
Essence de citron — J. Dumas [1 & 3].
Citronyl — Blanchet & Sell,[2] 1833.
Carven [19] — Schweizer,[4] 1840.
Hesperidene — Wright Piese,[11] 1871.
Citren [19] } Wallach.[15]
Hesperiden }
Limonen -- Wallach, 1884.
Citrene — Yoshida, 1885.
Rechts-Limonen — Wallach [22], 1888.

Dumas[1] stated (1833) that "Citrêne," the hydrocarbon from oil of lemon is isomeric with "camphêne," the hydrocarbon from turpentine oil, with this difference: the molecule of the former is but half as large as that of the latter. This distinction is shown by their different capacity for absorbing hydrogen chloride. He regarded the natural "citrêne" (dextrogyrate limonene) as being identical with the artificial hydrocarbon which he recovered from the hydrogen chloride addition-product (namely dipentene), and which he also designated as "citrêne."

Blanchet and Sell[2] (1833) designated as "citronyl" that hydrocarbon of the lemon oil which is capable of forming a solid compound ("festes

salzsaures citronenöl") with hydrogen chloride, and regard it as isomeric with "Dadyl" that hydrocarbon of turpentine oil which is capable of yielding a crystallizable compound with hydrochloric acid.

Soubeiran and Capetain (1840) distinguish for the first time between limonene and dipentene. They had determined the rotatory power of their original material (for the "essence de citron rectifiée $[\alpha]_D = 80°.916$ dextrorotatory), but found the "camphre de citron" (dipentene dihydrochloride) obtained from it, as also the regenerated "citrêne" (dipentene) to be optically inactive. The difference, they state, is the same as that between the "térébène" (o-Pinene) and the essence of turpentine (-Pinene). They also call attention to the fact that the "essence de térébenthine" (-Pinene) retains in the "camphre solide" (Pinene-monhydrochloride) its optical activity, and that "S'il est possible de supposer que l'essence de térébenthine soit entrée sans alteration dans le camphre solide, on ne peut se refuser à reconnaître que dans ancune de ses combinaisons l'essence de citron n'a conserva son état meléculaire primitif." Soubeiran and Capetain had thus recognized and pointed out the difference beeween the hydro-carbons we now designate as dextrogyrate limonene and dipentene, and had also indicated the inversion of one into the other. But, although they isolated and identified the dextrogyrate limonene from the oil of orange, they do not at all call attention to the identity of the same with that from lemon oil.

In 1840 Schweizer[4] isolated from the oil of caraway a hydro-carbon, which he designated "carven" (+ Limonene). By passing hydrogen chloride into it he obtained a dihydro chloride melting at 50° (Dipentene dihydro chloride). The hydro carbon regenerated from this compound by means of lime he regarded as unchanged carvene. Based upon his analyses and vapor density determinations he assigned to the "carven" the formula $C_{10}H_{16}$. Boiling point 173° C.

It is quite apparent from what has been stated above that the different capacity for the saturation of hydrogen chloride was regarded as chief distinction between pinene and limonene. Based upon the direct formation of dipentene dihydro chloride from turpentine oil, Berthelot[5] (1852) claimed that the distinction between turpentine oil and lemon oil, i. e., between pinene and limonene, was not at all essential. He seems to regard both as identical, though he admits a slight difference on account of the somewhat varying stability of the molecule of the two. As a further proof for the latter statement, he shows later that limonene is not as easily affected by heat as pinene[6-7].

Already in 1840 Völckel[8] had surmised the existence of a hydrocarbon besides carvol in the oil of caraway. In 1853[9] he pointed out the apparent genetic relations existing between carvol and this hydrocarbon, the so-called carvene (+ limonene). Although Völckel's formulas have long been discarded the fact remains and is of historic interest.

In 1864 Gladstone attempted to introduce order into the then already chaotic condition of the terpene literature. Based upon physical and chemical properties he classified the terpenes into three great groups. It is of special interest to note that he would regard the terpenes from sweet orange oil, lemon oil and the oil of citrus medica as identical rather than isomeric.

In 1871 Wright & Piese[11] oxidized hesperidene from orange oil (+ limonene) with chromic acid mixture, and obtained acetic acid. From this they conclude that the formula $\begin{matrix} CH.\ CH_3 \\ \| \\ (C_8\ H_{12}) \end{matrix}$ expresses in part "the grouping of the constituent carbon atoms." Nitric acid oxidizes hesperidene to oxalic and carbonic acids.

Two years later Wright[12] obtained from hesperidene besides acetic and formic acid a substance $C_{10}\ H_{16}\ O$ when oxidized with chromic acid mixtures. When oxidized with nitric acid he obtained oxalic acid and hesperidinic acid, $C_{20}\ H_{26}\ O_{17}$, *but no terephthalic acid.*

When a molecule of bromine is added a liquid non-characteristic dibromide is formed which when heated splits off hydrobromic acid and cymene results which is identical with the cymene obt. from pinene and "citrene" (+ limonene from oil of lemon). From this Wright concludes "that these three terpenes may all be regarded as dihydrides of cymene." The yield of cymene from "hesperidene dibromide" was 80 per cent. and from the cymene he obt. by oxidation 45 per cent of terephthalic acid. From the latter experiment he concludes that "the production of terephthalic acid "from cymene by oxidation shows that two 'lateral chains' are present; and as toluic acid is also obtainable from cymene, one of these must be methyl (since toluic acid gives rise to methyl-benzene toluene); cymene therefore is either a methyl propyl-benzene or a methyl isopropyl benzene."

As to some of these views, however, Oppenheim [13] has claim of priority. He had obtained "citrene cymol" by addition of bromine to "citrene" and then splitting off hydrobromic acid by means of anilin; also according to Kekulés method by adding iodine and splitting off hydroiodic acid with the aid of heat. In his oxidation experiments with dilute nitric acid he obtained not only terephthalic acid but also para-toluic acid and acetic acid. Neither "terpene cymol" nor "citrene cymol" therefore contain an etlyl group, but both have in para-position methyl and propyl. The formation of acetic acid makes it probable that the latter is isopropyl.

Already a year previous Oppenheim[14] had remarked that the terpenes were hydrocymols. Remarkable are, however his words which he wrote shortly after. "The fact, however, that until now para cymol has only been obtained from terpenes may well create the suspicion that even the mildest reaction according to which hydrogen may be abstracted, the action

of iodine on the terpenes, disturbes the molecular arrangement of the same and causes a rearrangement of the atoms which prevents us from recognizing the original structure of the terpenes."

In the seventies Tilden introduced a new class of terpene derivatives which proved of exceeding interest and importance. His nitrosylchloride addition products and the nitro terpenes obtained therefrom afforded a better means to distinguish the hydrocarbons of the pinene group from those of the limonene group. He showed also that the terpenes from orange oil, bergamot oil and caraway oil afforded the same nitrosylchloride addition product.

With the year 1884 there began a new era in the literature of terpenes and volatile oils. Wallach had succeeded in preparing a tetrabromide[17] of "cynene" $C_{10}H_{16}Br_4$ (now Dipéntene tetrabromide), a handsomely crystallizable body which melted at 124°. Soon after he obtained a tetrabromide from "hesperidene" (+ limonene), which crystallized in a very similar form, but melted at 104°. Wallach wrote at the time, "There seem to exist very close relations between "cynene" and "hesperidene," but no complete identity." In these tetrabromides we have, as it were, the key to our present knowledge of the terpenes. These two terpenes which for decades had been a stumbling block to chemists, were now characterized. The importance of these substances already becomes evident from the second contribution[20] of Wallach four months later. By means of the tetrabromide Wallach proved the presence of limonene in the fraction 175° of the following oils: lemon oil (so-called "citrene"), bergamot oil, caraway oil (so called "carvene"), dill oil, erigeron oil and in the oil of the leaves of pinus sylvestris.

Wallach showed, furthermore, that these fractions could be inverted into dipentene by means of heat (temp. of 250–270°) as was shown by means of the dipentene tetrabromide. Also by adding two molecules of hydrogen chloride and splitting off the same by heating with aniline and converting the resulting hydrocarbon into its tetrabromide.

Wallach then characterizes limonene in the following manner: "It boils between 175–177°, and possesses a lemon like odor. It produces a nitroso derivative which melts at 71°, and a tetrabromide which melts at 104°, and crystalizes in rhombic-hemiedric forms. Hydrogen chloride converts it in etherial solution into a dihydrochloride of *dipentene* which melts at 50°. Hesperidene, citrene, carvene, etc., are hereafter to be designated as limonene."

The true character of limonene, i. e. its position as the dextrogyrate member of the limonene group became apparent in 1888 when Wallach[22] recognized lævogyrate limonene as such and succeeded in the synthetical preparation of dipentene derivatives from its destrogyrate and lævogyrate components. The peculiar differences between the limonenes and dipentene as revealed in their derivatives, as also the singular

position of the dipentene derivatives when compared with the optically inactive derivatives of pinene and camphene must be considered later. It is no doubt largely due to these peculiarities that our knowledge of the relations existing between the members of the limonene group was so long retarded.

Lævogyrate Limonene.

Limonen — Wallach[2] 1884.
Citrene — Yoshida[3] 1885.
Links-Limonen — Wallach[4] 1888.

Apparently Deville[1] (1849) has first described lævogyrate limonene, without, however, recognizing its peculiar relation to dextrogyrate limonene, then chiefly known as citrene. From elemioil Deville obtained a hydrocarbon which had the constant boiling point 174°, and to which he assigned the composition $C_{10}H_{16}$. At 11° it had the specific gravity 0.849; coefficient of refraction 1.4719 at 14°C; specific rotatory power -90°, 30; vapor density 4.84 (calculated 4.76). With hydrogen chloride he obtained a compound to which he assigned the formula $C_{10}H_8HCl$, and of which he states: "La rotation de a camphre est nulle comme celle du camphre de citron, son isomère."

In 1884 Wallach demonstrated by means of the tetrabromide reaction the presence of limonene in the oil from pinus sylvestris without, however, paying attention to its optical properties. In the following year Yoshida[3] isolated from camphor oil a fraction 172-173° of the composition $C_{10}H_{16}$ of which he writes (p. 787): "This hydrocarbon is probably chemically identical with citrene, the main constituent of the so-called essence of lemon. The point of difference from the lemon oil citrene is its lævorotatory power, viz. $[\alpha]_j = -68.3°$, but this can be looked upon as a physical difference between the two, such cases being common among the optically active terpenes." Yoshida obtained from this fraction a "Dihydrochloride of Citrene," $C_{10}H_{16}{}_2HCl$ (melting point 58-59° C.), but did not succeed in making the nitroso-chloride. By the addition of one molecule of bromine and splitting off hydrobromic acid he obtained cymol, which upon oxidation yielded 40 p. c. terephthalic acid.

In 1888 Wallach[4] showed that lævogyrate limonene occurs in the oil from the leaves of pinus picaea. "The lævogyrate limonene has a constant boiling point of 175-176°, its spec. gravity was 0.846[5] at 20°, $[\alpha]_D = -105°$. Tetrabromide and nitroso-chloride clearly demonstrate the opposite character of the hydrocarbon with reference to its dextrogyrate congener.

Dipentene.

Citrêne [1] — J. Dumas, 1833.
Citronyl [2] — Blanchet and Sell, 1833.
Kautschin [3] — Himly, 1835.
Citrêne [4] — Soubeiran and Captain, 1840.
Carven [5] — Schweizer, 1840.
Cynèn [6] — Völckel, 1854.
Cinæben [7] — Hirzel, 1854.
Caoutchine [8] — Williams, 1860.
Cynen [9] — Græbe, 1872.
Isotérébenthène [10] — J. Riban, 1874.
Di-isoprène [11] — Bouchardat.
Terpilène [12] — Bouchardat.
Dipentene [12] —
Terpene [12] —
Terpilene —
} Tilden.
Citrene [13] — Watts, 1886.
Cynen [14] — Wallach, 1884.
Cajeputen [15] — Wallach.
Cinen [16] — Wallach, 1884.
Dipenten [17] — Wallach, 1884.

In an article "Sur la combinaison de l'essence de citron avec l'acide muriatique," Saussure[18] (1820) states that from the "muriate citré" (dipentene dihydrochloride) the hydrochloric acid can be removed *in part* by distillation with caustic lime.

In 1833 J. Dumas reports on the regeneration of the hydrocarbon "citrêne" (dipentene) from the "camphre de citron" (dipentene dihydrochloride) by repeated distillation with caustic potassa and caustic baryta. He assigns to the regenerated hydrocarbon the formula $C_5 H_4$ and makes about it the following concluding remark: Si 'l est donc certain, que cette matière, qui fait presque totalité de l'essence de citron, est isomerique avec celle, qui forme de son côté la presque totalité de l'essence de térébenthine, avec cette difference, que la condensation des éléments est double dans la dernière." From these remarks it becomes quite evident:

1. That Dumas recognizes the isomerism between pinene and limonene, resp. dipentene.

2. He supposes the limonene present in the oil of lemon to be identical with the dipentene regenerated from the dipentene dihydrochloride obtained by the addition of hydrogenchloride to, and by the inversion of limonene.

3. He recognizes the fact that limonene will absorb again [illegible]nch hydrogenchloride as pinene. Laboring under the false suppositio[illegible] that

a molecule of hydrocarbon can combine with but one molecule of hydrogen chloride, he comes to the conclusion that the molecule of limonene, resp. dipentene is but half as large as that of pinene.

Blanchet and Sell [2] (1833) obtained independently the same results and come to the very same conclusions.

In 1835 Himly [3] obtained from the products of dry distillation of caoutchouc a fraction 168–171°. Saturated with hydrogen chloride this yielded "salysaures Kautschen," (dipentene dihydrochloride) from which the hydrocarbon can be regenerated by distillation with caustic potassa and rectification over metallic potassium. The regenerated hydrocarbon was colorless, possessed a limonene odor; spec. gravity 0.8423 at 16°; boiling point 171°; vapor density 4.461. He assigns to it the formula $C_5 H_8$.

An observation of Soubeiran and Captain (1840) is of great interest, viz.: that the hydrocarbon regenerated from the *optically inactive* "camphre de citron" (dipentene dihydrochloride) is likewise *optically inactive* and is thus distinguished from the "essence de citron" (+ limonene).

Schweizer,[5] however (1840), still regarded the dipentene regenerated from the dihydrochloride as identical with the "carvene" (+ limonene) from which the dihydrochloride had been prepared.

In 1848 List [19] observed that when the "chlorwasserstoff verbindung des *Terpins*" (dipentene dihydrochloride) is distilled with caustic lime, or when anhydrous *terpin* is distilled repeatedly with anhydrous phosphoric acid a volatile oil of the composition "$C_{20} H_{16}$" is formed.

In the following year (1849) Deville [20] regenerated the hydrocarbon from the "camphre de citron" (dipentene dihydrochloride) prepared from terpin hydrate and declares this hydrocarbon dipentene to be identical with "l'essence de citron" (+ limonene). This, he states, "furnishes the means to transform the essence of turpentine into the essence of lemon." (That Deville, who made considerable use of the polariscope in his investigations, apparently gives no heed to optical properties in this case is rather surprising.)

In 1860 Greville Williams [8] in his researches on "Isoprene and Caoutchine," confirms Himly's analysis. He states further that "caoutchine" (dipentene) decolorizes four equivalents of bromine; that by the alternating action of bromine and sodium cymol is obtained, which upon oxidation yields "insolinic acid." Sulphuric acid converts "caoutchine" into a viscid oil. Small quantities of an acid "$C_{20}H_{16}S_2O_6$" are also formed from which a calcium salt, "$C_{20}H_{15}CaS_2O_6$" was made. Williams assumes that the heat effects a tearing assunder of a polymeric body (caoutchouc), and that the substances which are formed stand in a simple relation to the mother substance.

Tilden [11] in 1882 repeated some of the experiments of Greville Wil-

liams and of Bouchardat pertaining to the decomposition of terpenes at high temperatures. In an article [19] (1884) he makes the following very important claim: "There is no doubt that the di-isoprene of Bouchardat and the dipentene which I have just described, are identical with terpilene, the optically inactive hydrocarbon into which the terpenes and citrenes are convertible."

In 1886 Watts[21] showed dipentene (called by him "citrene,") to be present in the oil of the leaves from citrus limetta. He states that it resembles "citrene" (+limonene) very much, but behaves differently toward polarized light.

Bouchardat and Lafont[22] (1886) studied the action of chromic acid on lævogyrate pinene. Among other products they obtained a hydrocarbon $C_{10} H_{16}$ which boiled between 174-178°, $[\alpha]_D = -56°$ and combined with hydrochloric acid to form a "chlorhydrate de terpilène ou de citrène" which melted at 47°, (dipentene dihydrochloride). It is quite evident that this hydrocarbon consisted of a mixture of limonene and dipentene. The "isoterpenes" of Flawitzky[23] obtained by the dehydration of the so-called "terpenhydrate" (evidently mixtures of the opt. inactive terpinene with the opt. active ones,) are no doubt similar mixtures.

Bouchardat and Voiry[24] (1888) bring nothing new when they state that dipentene dihydrochloride when heated with alcoholic potash yields a "carbure terpilénique" (impure dipentene). This fact simply shows that the deplorable custom of dishing up old facts with new names has not entirely ceased[25]. In his articles "Sur l'essence d'Eucalyptus globulus"[26] and "Sur l'essence de cajeput"[27] Voiry even surpasses his master in scientific dishonesty.

In a historical study of dipentene wormseed oil (Oleum cinae) must not be left unconsidered. It constitutes as it were a special chapter in the history of this hydrocarbon. It will, therefore, be necessary to turn back and study the development of our knowledge concerning dipentene ("cynene") in connection with this oil.

In 1841 Wöhler[27] communicates the results of Völckel's analysis of the oil. He states that "it does not appear to stand in any simple relation to santonin" but consists of a substance "$C_9 H_{15} O$" admixed with small quantities of another oil." In 1853 Völckel[28] assigned to the chief constituent of the oil boiling at 174-175° the formula "$C_{12} H_{10} O$." In the following year in an article "Veber das Cynen" he treats of a hydrocarbon obtained by distilling wormseed oil repeatedly with anhydrous phosphoric acid. After successive treatment of the crude product with *sulphuric acid*, water and chloride of calcium in order to "*purify*" ? it, the "cynèn" distilled completely between 173-175°. He assigns to it the formula $C_{12} H_9$. "Das Cynèn ist demnach aus dem Wurmsamenöl: $C_{12} H_{10} O$ durch das Ausscheiden vom 1 Aeq. Wassertoff and 1 Aeg. Sauertoff als Wasser entstanden."

Hirzel[7] (1854) regards the rectified "Ol Cinae" to consist of a mixture of a hydrocarbon "Cinaeben" "$C_{10}H_8$" with "Cinaeben campher," "$C_{10}H_9O$." The latter when distilled with anhydrous phosphoric acid yields among other products "Cinaeben."

Kraut's [29] analysis of wormseed oil (1862) would lead him to the formula "$C_{24}H_{20}O_2$," However, his vapor-density determinations bring him to the conclusion that the oil is a mixture of a substance "$C_{20}H_{16}O_2$," with little of a hydrocarbon "(probably of the formula $C_{20}H_{16}$)."

Kraut and Wahlforss [30] verify Völckel's statement in so far as the oil when distilled with anhydrous phosphoric acid yields a hydrocarbon. Their analyses and vapor-density determinations, however, lead them to the formula "$C_{10}H_{16}$." "*This hydrocarbon is optically inactive.*"

Graebe [9] replaced (1872) phosphorus pentoxide by phosphorus penta sulphide. He obtained a hydrocarbon which he supposed to be "cynen." However it must have been cymol, since it yielded terephthalic acid upon oxidation. Graebe's "cynen sulfosaeure, $C_{10}H_{15}(SO_3H)$" when fused with caustic potassa did not yield a phenol of "cynen" but of cymol, consequently it must have been a derivative of the latter.

Faust and Homeyer [31] prepared "Cynen" according to Graebe's method and identified it as cymol by means of paratoluic acid and of cymol sulphonate of barium. They believe that there can be no further doubt as to the identity between "cynen" and cymol.

Hell and Stürcke[32] (1884) again use phosphorus pentoxide as dehydrating agent and obtain the hydrocarbon $C_{10}H_{16}$. Fuming sulphuric acid blackens it and converts only a part of it into the sulphonic acid. The barium salt is stated to be identical with the barium cymol-sulphonate obtained by Kraut from caraway oil. Hell and Stürcke arrive at the conclusion that by the action of phosphorus pentoxide upon wormseed oil "cynen" and not cymol results, but that the sulphuric acid by abstracting two hydrogen atoms oxidizes the former into the latter[34].

Hell and Ritter[35] (1884) have observed that when hydrogen chloride is passed into wormseed oil, this becomes heated and $C_{10}H_{18}O$. H Cl is not formed but water is split off and "cynendihydrochlorid" $C_{10}H_{18}Cl$ (melting point 50–51°) results (dipentene dihydrochloride). From this "cynen" (dipentene) can be obtained by distillation wth caustic soda and rectification over metallic sodium. These reactions are to be expressed by the following equations.

1. $C_{10}H_{18}O + HCl = C_{10}H_{18}Cl(OH)$. [a chlorhydrin.]
2. $C_{10}H_{18}Cl(OH) + HCl = C_{10}H_{18}Cl_2 + H_2O$.
3. $C_{10}H_{18}Cl_2 = C_{10}H_{16} + 2HCl$.

About the same time with Hell, Wallach[36] began his investigations of the terpenes. In part they meet on the same ground, in part they supplement each other. However, where Hell feigned analogies to exist

among terpenes or their derivatives Wallach removed all doubts and thus laid a foundation for a systematic investigation of the terpenes.

Wallach showed that the composition of the hydrogenchloride addition product of cineol $C_{10} H_{18} O$, the chief constituent of wormseed oil, is expressed by the formula $(C_{10} H_{18} O)_2 H Cl$. When heated by itself this compound splits off water and hydrochloric acid as expressed by the following equation:

$(C_{10} H_{18} O)_2 H Cl = 2 H_2 O + H Cl + 2 C_{10} H_{16}$ whereby cinene (dipentene) is formed. Cineol adds two bromineatoms to form a bibromide which is deliquescent. Water and hydrobromic acid split off and a tetrabromide $C_{10} H_{16} Br_4$ is formed which melts at 125.5°. This tetrabromide is identical with the one obtained by the addition of bromine to the hydrocarbon cynene (dipentene). At the same time Wallach showed that cajeputol[37] is identical with cineol, also cajeputene with cynene. The limonene odor of cinene (dipentene) lead Wallach to surmise the relations existing between this hydrocarbon and hesperidene (+limonene). The preparation of limonene tetrabromide[38] melting at 104° proved these suppositions to be true.

The importance of these tetrabromides soon became apparent. Already in his second contribution Wallach showed conclusively by means of the tetrabromide reaction that dipentene was formed in a large number of reactions. Wallach, at that time, characterized dipentene as follows:

"It boils at 180–182°[39]. The odor resembles that of limonene. It combines with bromine to form a tetrabromide which crystallizes in the rhombic system and melts at 125–126°, also with two molecules of hydrogen chloride, without being changed thereby, to dipentene dihydrochloride which melts at 49°. At high temperatures it polymerizes without being previously modified."[40]

Dipentene is classified here as the special hydrocarbon of the dipentene group, whereas the closely related "hesperiden" (+ limonene) is placed in the limonene group.[40] The reason for such a separation is quite apparent. The inactive modifications of pinene and camphene are not essentially different from their optically active modifications. Lævogyrate limonene was not yet known as such. It was only with the discovery of this terpene on the part of Wallach[41] that the true relations existing between dipentene and the optically active limonenes could become wholly apparant. Whereas the relations existing between o-pinene and ± pinene are those of o-tartaric and to ± tartaric acids, the relations existing between o-dipentine and ± limonene are explained by those existing between o-racemic acid and the optically active tartaric acids.

Dipentene, therefore, is not optically inactive limonene in the same sense in which o-pinene and o-camphene are the optically inactive modifications of the respective groups. That dipentene derivatives, pre-

pared synthetically from the optically active modifications, have but a simple molecule has been shown by Wallach in connection with optically inactive carvoxime.[43] On account of the peculiar position of the optically inactive members of derivatives from the limonene group he has retained the designation "*dipentene*" in preference to *0-limonene*, for optically inactive limonene derivatives corresponding to those of optically inactive tartaric acid may yet be found.

Properties.

The hydrocarbons of the limonene group are colorless liquid terpenes of an agreeable lemon-like odor.[1] Two of the three are optically active, being opposite in character. The physical constants of the limonenes have been determined as follows:

Boiling point, 175—176°.[2 3]

Spec. gravity at 20° 0,846.[3]

$[\alpha]_D = 105°$ [3] resp. $+ 106.8°$ [2]

Coefficient of refraction n_D 1.47459.[3]

Molelecular refraction $\frac{(n^2-1)p}{(n^2+2)d}$ 45.23.[3]

Chemically the two modifications are identical. They add one molecule of hydrogen chloride without losing their optical activity. When every trace of moisture is avoided they will not add more.[4] In the presence of moisture, however, they add two molecules of hydrogen chloride and thereby become optically inactive, i. e., are converted into a dipentene derivative, dipentene dihydrochloride. The dibromine addition products appear to be viscid liquids and are therefore not characteristic. When hydrobromic acid is split off cymol results.[13] The tetrabromides, however, are very characteristic.[5] Optically[6] as well as crystalographically[7] their character is opposite. The limonenes add also nitrosyl chloride, apparently but one molecule. However, two addition products of $\left\{\begin{matrix}NO\\Cl\end{matrix}\right.$ result, an α—and a β—nitroso-chloride. With bases both yield the same α—and β—nitrolamines. Like limonene the monhydrochloride is still capable of adding the groups $\left\{\begin{matrix}NO\\Cl\end{matrix}\right.$ and $\left\{\begin{matrix}NO\\O(NO)_2\end{matrix}\right.$.

In this case, however, but one hydrochlor-nitroso chloride or hydochlor-nitrosate resp. results. The molecule of hydrogenchloride can also be added after the addition of the NO Cl group, viz., by the nitrolamines. Thus e. g. the α-nitrolanilid will yield an α-hydrochlor addition product, the β-nitrol anilid a β-hydrochlor addition product. Of these the α-base is identical with the one obtained from the hydrochlor-nitrosochloride.[8] These peculiarities, which have thus far been observed in connection with limonene group only indicate a different behavior of the two double bonds toward regents.

The behavior of the limonenes toward water is similar to that toward the hydrohalogens. After the addition of one molecule of water the hydration product still appears to be a limonene-derivative.[9]

The addition of a second molecule of water makes it a dipentene derivative. Terpin and its hydrate are both optically inactive and upon dehydration yield dipentene but no limonene.

The transformation of limonene to dipentene is termed *inversion* and seems to be brought about easily by the presence of acids. Thus e. g. a partial inversion takes place in the preparation of the nitrosochlorides and nitrosates, and especially of the hydrochlor nitrosochlorides and nitrosates[10]. Limonene can also be inverted into terpinene whereby dipentene results as intermediate product[11]. Indirect inversion into terpinolene[12] also seems to take place under favorable conditions. If the isoterpenes of Flawitzky[9] are but impure limonenes then the pinenes can be inverted into limonene by means of alcoholic sulphuric acid. It thus becomes apparent that limonene though a relatively stable terpene is by no means the most stable.

Dipentene closely resembles the limonenes in most of its properties Boiling poing 178°, spec. gravity 0.845 at 20°, $n_D = 1.47308$. It is readily distinguished from the limonenes by being optically inactive. Whether dipentene is physically identical with optically inactive limonene, resulting from a mixture of equal parts of dextro-and lævogyrate-limolimonene has not yet been decided. Chemically they are identical. Since in all characteristic cases the optically inactive limonene derivatives have been shown to be identical with the corresponding derivatives obtained from dipentene the term dipentene only will be used hereafter. The dihydrochloride is identical with the one resulting from the addition of two molecules of hydrogen chloride to the limonenes. The tetrabromide, however, is distinguished from the limonene tetrabromides in form, melting point and solubility. What has been mentioned of the limonenes with reference to nitrosylchloride also holds true for dipentene. It might yet be stated that all dipentene derivatives can also be obtained by mixing solutions of equal parts of the corresponding detro- and lævogyrate limonene derivatives. It is to be supposed that dipentene like limonene will add water to form terpin hydrate, but this has not yet been demonstrated.

Limonene as well as pinene and phellandrene can be inverted into dipentene, which in turn can be inverted into terpinene only. Dipentene is therefore one of the most stable terpenes.

OCCURRENCE.

Dextrogyrate Limonene:

In the oil of Citrus Limonum:[16]
" aurantium.[17]
" medica.[18]
" bigaradia sienensis.[19]
" " myrtifolia.[19]
} 15
" Bergamia.[20]
Carum Carvi.[21]
Anethum graveleus (Dill oil).[22]
Erigeron Canadense.[23]

Lævogyrate Limonene:

In the oil of Laurus camphora (camphor oil).[24]
Pinus sylvestris.
Pinus picea.
} ("Fichtennadel oel").[25]

Dipentene:

In Camphor oil.[29]
" Cubeb oil.[30]
" Elemi oil.[31]
" Olebanum oil.[32]
" Swedish turpentine oil (modified natural product).[33]
" Russian turpentine oil[34] (modified natural product).
" Oil from leaves of Citrus Limetta.[35]
" Oil of black pepper.[36]

The statements that Ol. Cinae, Ol. cajeputi and Ol. Eucalypti contain dipentene as natural product, are without proof.[37]

The presence of *limonene* can readily be ascertained in the fractions of volatile oils boiling about 175° by Tilden's nitrosylchloride reaction as modified by Wallach.[26] If the yield is not too small the α-nitrosochloride can be recrystallized from ether and recognized by its crystalline form.[27] The conversion of the crude nitrosochloride into carvoxime is characteristic but not easily performed. The double decomposition of the crude nitrosochloride with benzylamine is much simpler.[28] The α-nitrol-benzylamine base crystallizes in dull needles which melt at 93°. The tetrabromide reaction is also very characteristic but not as easily and readily performed as the one mentioned last.

Dipentene is found in fractions boiling from 175–180° It is characterized by means of its tetrabromide[38] melting at 124°, by means of its nitrosochloride and the benzylamine base obtained therefrom.[39] The α-base crystallizes well from dilute alcohol in colorless transparent crystals, melting at 109–110°.

Methods of Formation.

If the "Isoterpenes" of Flawitzky [9] are impure limonenes, then the latter can be obtained by inversion of the optically active pinenes through the optically active terpineols (terpene hydrates of Flawitzky).

Dipentene being more stable than its optically active modifications results from a large number of reactions:

I. Polymerisation of Isoprene, a hemiterpene. [40]

II. Inversion of less stable terpenes, viz.:

1. By means of heat: direct inversion into dipentene.

2. By means of acids—
- **a. Hydrohologen acids: into dipentene dihydrochloride, etc.**
- **b. Sulphuric acid: apparent direct inversion.**

3. By means of water in presence of acids (e.g. nitric acid) conversion into terpin hydrate.

According to these methods pinene, [41] limonene [42] and phellandrene [43] can be converted into dipentene.

III. Destructive distillation of polymerized terpenes: e. g. Káoutchouc (Himly's "Kautschin").

IV. Regeneration of dipentene from derivatives:

1. Removal of hydrohalogen from dipentene dihydrochloride and dihydrobromide by means of alcoholic potash,[44] sodium acetate [45] or anilin.[46]

2. Dehydration of *O*-Terpineol or terpin, resp. terpinhydrate [47]

Methods of Preparation.

Dextrogyrate limonene is obtained by fractional distillation. Oil of sweet orange consists almost entirely of +limonene. The "carvene" of commerce and Erigeron oil are also very rich in +limonene and relatively cheap.

Levogyrate limonene is thus far obtained from "Fichtennadel öl" only.

Dipentene is best obtained by decomposition of its dihydrochloride or bromide by boiling with anilin.[46] The use of sodium acetate and glacial acetic acid[45] cause the formation of byproducts. It is rather difficult to remove the last traces of halogen.[5]

HYDROHALOGEN ADDITION PRODUCTS.

Monohydrochlorides.

History:

The question whether a limonene monhydrochloride analogous to pinene-monhydrochloride can exist has long remained an open one. Considerable speculation has been indulged in concerning the liquid byproducts, resulting in the preparation of dipentene-dihydrochloride. Some regarded it as a monhydrochloride, others as an isomeric liquid

dihydrochloride. Those who supported the latter view termed it "camphre-liquide de citron" in opposition to the "camphre solide de citron" (crystalized dipentene dihydrochloride). From this "camphre liquide de citron" Soubeiran and Capitain[1] went so far as to prepare the hypothetical hydrocarbon "citrylène": spec. gravity 0.88, boiling point 168°, vapor density 5.08, optically inactive. More than this, they created a group of liquid camphors, in distinction to the solid and artificial camphors.

Characteristic as well as interesting are Berthelot's[2] views (1882). He had succeeded in preparing dipentene-dihydrochloride from pinene. From this he concludes that the difference between pinene and limonene ("essence de citron") is not "essentielle." Consequently limonene *must* yield a mono hydrochloride, analogous to artificial camphor. However "sa préparation est difficile, car elle parait se produire seulement en faible proportion et *d'une manière accidentelle.*"

That under such conditions it is perfectly impossible to interpret all older statements in the light of present knowledge is certainly apparent. A complete catalogue of all the literature that has reference to this particular subject would therefore be useless. In most cases it may be assumed that these liquid products were mixtures of mono- and dihydrochlorides.

A statement by S. de Luca[3] (1887) appears to be more rational. When he passed dry hydrogen chloride into relatively pure limonene from the citrus bigaradia *no solid compounds would result.* Crystallized dipentene-dihydrochloride, however, resulted when the oil was shaken with aqueous hydrochloric acid. de Luca, however, makes no statements regarding composition and character of this liquid chloride. Ribans[4] statements (1874) are more important. By passing dry hydrogen chloride into limonene a liquid monhydrochloride resulted which could be converted into crystallizable dihydrochloride by treatment with moist hydrogen chloride. Bouchardat[5] (1875) claims to have obtained a liquid monhydrochloride and a solid dihydrochloride. Maissen[6] (1883) also obtained a hydrohalogen addition-product which was *not* saturated. From these statements by de Luca, Berthelot and Maissen it would seem that the hydrogen chloride must be dry to yield a monhydrochloride. Others[7], however, who according to their statements employed dry hydrogen chloride obtained dipentene-dihydrochloride and no monhydrochloride. It is therefore not at all surprising that Wallach[8] (1887) after an unsuccessful attempt to prepare a monhydrochloride denied the existence of such a compound. The study of Maissens compound (dipentene-hydrochlor-nitrosate), however, again brought up this question.

As a result of these investigations it became apparent that a monohydrochloride of limonene could exist, and that it was an *unsaturated* compound. The understanding of Riban's and Maissan's experiments had

to make the latter fact apparent, but Wallach first called attention to it. Physical as well as chemical characteristics were first studied by him. Wallach's monohydrochloride was, as I have shown, chiefly dipentene-monhydrochloride.[10] The optically active monhydrochlorides were first described by me.[11]

Properties.

Since there is no criterion to ascertain the purity of the monhydrochlorides the following data found for the three physical isomers will have to be accepted at present:[11]

+ Limonene-monhydrochloride.

"A colorless, mobile liquid of faint limonene odor. It boils at 97–98° under pressure of 11–12 mm. Spec. gravity 0.973 at 17.8°; $[\alpha]_D = +39.5°$."

—Limonene-monhydrochloride.

"This corresponds with the dextrogyrate compound in all but its optical properties. The rectified product boiled at 95–96° under a pressure of about 11–12 mm.; spec. grav. 0.982 at 16°; $[\alpha]_D = +40.0°$."

Dipentene-mouhydrochloride.

It was prepared by mixing equal parts of the above dextrogyrate and lævogyrate compounds. "The mixture was optically inactive; spec. gravity 0.982 at 16.5°; boiling point 98° under pressure of 12 mm." Wallach[12] ascertained the physical properties of a *dipentene* compound to be as follows: Boiling point 90° under pressure of 11 mm.; spec. grav. 0.98; $n_c = 1.4789$, molecular refraction 49,86, calculated for an unsaturated compound $C_{10}H_{17}Cl$ 50,28.

Chemically the monhydrochloride behaves like an unsaturated compound. Under the conditions, however, which are most favorable to its formation it will not add a second molecule of hydrogen chloride.[11] But in the presence of moisture it adds another molecule and the limonene derivative is thereby converted into a dipentene derivative. It also adds $\left\{\begin{matrix} H \\ Br \end{matrix}\right.$[13] $\left\{\begin{matrix} NO \\ Cl \end{matrix}\right.$[14] and $\left\{\begin{matrix} NO \\ O\,(NO_2). \end{matrix}\right.$[15] Chlorine very likely also can be added, but this apparently substitutes at the same time.[16] Water is not added directly. In the presence of water the chlorine is substituted by hydroxyl,[16] and the aqueous hydrochloric acid acts upon the terpineol to form terpin hydrate.[17]

The monhydrochlorides polymerize in a very peculiar manner.[18] Hydrogen chloride is split off at the same time and partial inactivity results when the underlying hydrocarbon was optically active.

The hydrogen chloride is not easily removed and traces of chloride are apt to remain. The regenerated hydrocarbon is a mixture of limonene and dipentene[19].

Preparation.

When *dry* hydrogen chloride is passed into a *dry* solution of limonene or dipentene in carbon disulphide the monhydrochloride alone results. For technical details compare the original.[20] Dipentene monhydrochloride can also be prepared by splitting off a molecule of hydrogen chloride from dipentene dihydrochloride[21].

Identification.

The monhydrochlorides can easily be identified by means of the hydrochlornitrolaminebases. The preparation and purification of the hydrochlornitrolbenzylaminebase is easily carried out[22].

Dipentene-dihydrochloride.

Synonyms.

Muriate Citré — Th. de Saussure, 1820.
Camphre de Citron — J. Dumas, [2] 1833.
Citrêne chlorhydrate — J. Dumas, [3] 1833.
Festes salzsaures Citronenoel — Blanchet & Sell, [4] 1833.
Salzsaures Kautschin — Himly, [5] 1835.
Hydrochlorate de Citrène — Laurent, [6] 1837.
Camphre solide [7] de citron — Soubeiran and Capitain. [8] 1840.
Chlorwasserstoffsaures Carven — Schweizer, [9] 1840.
Chlorwasserstoff Terpin — List [10] 1848.
Bichlorhydrate d'essence de Térébenthine — Berthelot, [11] 1852.
Dichlorhydrate de terpilène — Berthelot, [12] 1861.
Zweifach chlorwasserstoffsaures Terpilen — Oppenheim, [14] 1864.
Dihydrochloride of citrene — Yoshida, [15] 1885.
Cynen dihydrochlorid — Hell & Ritter, [16] 1884.
Dipenten-Dihydrochlorhydrat — Wallach, [17] 1884.
Chlorhydrate de terpelène — Bouchardat & Lafont, [18] 1886.
Dipenten-Dihydrochlorid — Wallach [17] 1887.

History:

Dipentene dihydrochloride is one of the oldest characteristic terpene derivatives. The so-called artificial camphor, the pinene monhydrochloride alone has claim to priority.[19] In an article "Sur la combinaison des acides avec les substances végétales et animales." Thenard in 1807 mentions a crystalline substance which resulted upon the absorption of hydrogen chloride by lemon oil. There can scarcely be any doubt as to the identity of this substance. At least Blanchet and Sell[4] mention Thenard as the discoverer of the compound under consideration. The

fact that Thenard recognized that the hydrochloric acid was *added* without causing a decomposition of the molecule adds to the interest of the discovery.

In 1820 Saussure[1] prepared dipentene dihydrochloride in pure form and described the same. He calls attention to the physical differences between this "muriate citré" and the "muriate térébinthiné." From it he also regenerated the hydrocorbon.

J. Dumas,[2] in 1833, accepts the formula $C_5 H_4 + \frac{1}{2} H \frac{1}{2} Ch$ for the "camphre de citron."

In the same year Blanchet and Sell[4] characterize the "salzsaure Citronenöl" as follows: "From ether it crystallizes in laminae with a silver lustre and of tuberose-like odor. It melts at 43° and sublimates at 50° without decomposition," etc. Percentage of chlorine 33.5 p. c.; formula $C_5 H_8 + Cl H$. Thenard has tried to ascertain the composition of the compound by noting the quantity of hydrogen chloride absorbed by the oil. Saussure destroyed the substance with nitric acid and precipitated the chlorine as silver chloride. He obtained 27.6 p. c. chlorine. Blanchet and Sell employed the lime method. These chemists also supposed that by the action of hydrogen chloride upon lemon oil two solid compounds are formed, the one of which decomposes into hydrochloric acid and oil when recrystallized from warm alcohol, the other being more stable. The latter is termed "salzsaures citronyl" (the substance under consideration), the other "salzsaures Citryl."

Himley[21] (1835) obtained "Salzsaures Kautschin" by passing hydrogen chloride into "Kautschin" (dipentene) and regenerated the hydrocarbon by distillation with lime and rectification over potassium.

Soubeiran and Captain[5] (1840) mention the readiness with which dipentene dihydrochloride decomposes: "Il suffit même d'évaporer une dissolution alcoolique de ce camphre pour qu'il soit détruit en partie," etc. They do not accept Blanchet and Sell's view regarding the mixture of two isomers. They recognize the fact that the "camphre de citron" and also the regenerated "citrene" are optically inactive.

Schweizer[9] (1840) assigns to his "chlorwasserstoffsaures Carven," the formula $C_{10} H_{16} + Cl_2 H_2$. He regards it as *isomeric* with the solid compound obtained by the action of hydrogen chloride upon lemon oil, copaiva oil, and orange oil, with which it corresponds more or less in some of its properties.

List[10] (1848) regards the chlorhydrate "$C_{20}H_{12}Cl_2$" obtained from the terpin as *isomeric* with the one obtained by Blanchet and Sell and by Dumas. He claims cyrstallographic differences, also differences in melting points and solubility.

Deville's observation of 1849 is of some interest: "Les hydrates de térébenthine donnent avec l'acide chlorhydrique de l'eau et du camphre de citron dont on peut retirer une huile qui par ût identique

avec l'essence de citron elle-même, ce qui fournit le moyen de transformer l'essence de térébentine en essence de citron."

Berthelot [11] obtained (1852) dipentene dihydrochloride directly from turpentine oil by shaking the latter with aqueous hydrochloric acid, or by passing hydrogen chloride into a solution of turpentine oil in ether, alcohol or glacial acetic acid.

Trying to replace the three molecules of "water radicles" in terpin hychlorine, Oppenheim [14] (1862) always obtained the dihydrochloride of dipentene.

These extracts and remarks may afford sufficient insight into the older literature of the dihydrochloride of dipentene. To give complete literary references up to date would be useless. From the above it becomes obvious that with a better knowledge of this compound some light was shed over the relations of terpenes in general. It must also be obvious, however, that for many it was a stumbling block and brought about greater confusion. Some chemists indeed recognized the identity of this compound from whatever source they obtained it, others denied the same. In the imaginations of some there were as many dihydrochlorides as there were terpenes, and these were limited only by the number of volatile oils containing hydrocarbons of the formula $C_{10}H_{16}$.

In spite of Berthelot's ideas Gladstone's [24] (1864) classification of the terpenes gained ground more and more. According to this dipentene dihydrochloride was regarded as the characteristic addition product of "citrene" (+ limonene) and allied terpenes, whereas artificial camphor was taken as characteristic derivative of the "terpenes" (pinene and allied terpenes.)

In the following twenty years little was added to a better understanding of this compound. A full understanding was possible only after the discovery of lævogyrate limonene, (1888) i. e., after the completion of the limonene group and synthesis of dipentene derivatives.

Properties.

Dipentene dihyrochloride crystallizes in pearly laminæ which melt at 50°.[25] It is insoluble in water, soluble in alcohol and ether, readily soluble in chloroform, from which solution it can be precipitated with methyl alcohol. Its presence effects a decrease of the melting-point of other substances.[26]

Chemically, dipentene dihydrochloride behaves like a saturated compound, and as a terpene derivative it is relatively stable. By splitting off one or both hydrogen chloride molecules it is converted back into unsaturated compounds. Heated by itself,[28] or in alcoholic solution.[29] it decomposes into its components, dipentene and hydrogen chloride. Caustic potassa and anilin split of hydrogen chloride, but the last traces of chlorine are very difficult to remove.[30] Solution of permanganate of potassium attacks it readily.[31]

Methods of formation:

I. Addition of hydrogen chloride:

1. To the monhydrochlorides of the limonene group.[32]
2. To the hydrocarbons of this group.[33]

The optically active hydrocarbons are hereby inactivated. The inc rect formation from cineol[34] is to be classed with 2, since the hydrog chloride acts first as a dehydrating agent forming "cinene" (dipenten

II. Esterification of the diatomic alcohol terpin and its hydrate:

1. By means of hydrochloric acid.[35]
2. By means of the tri- and pentachlorides of phosphorus.[36]

Ad I and II. The formation from the terpineols[37] no doubt consists an esterification of the monatomic alcohol and subsequent addition of second molecule of hydrogen chloride.

III. Inversion and addition:

e. g. From pinene,[38] phellandrene,[39] and probably from terpin lene.[40]

Preparation.

Larger quantities of dipentene dihydrochloride are rationally pr pared by passing hydrogenchloride over (not into) a solution of limone in one-half its volume of glacial acetic acid. A rise in temperature the solution must be avoided to prevent the formation of oily product After the solution has congealed to a crystalline mass it is poured in water and the drained chloride is purified by dissolving it in alcohol an precipitating with water.[41]

Small quantities can be readily purified by dissolving in chlorofor and precipitating the solution with methyl alcohol.

Dipentene-Dihydrobromide.

Dibromhydrate de terpiline, Berthelot,[42] 1861.
Zweifach bromwasserstoffsaures terpilen, Oppenheim,[14] 1864.
Cynen-dihydrobromid, Hell and Ritter,[16] 1884.
Dipenten-dihydrobromid, Wallach,[17] 1887.

History.

Dipentene-dihydrobromide was first prepared by Berthelot[42] from te pinhydrate analogous to the chloride. In the following year (186 Oppenheim[14] prepared it from terpinhydrate with tri- and penta bromid of phosphorus. In 1884 Hell and Ritter[16] prepared it from cine analogous to the chloride. Wallach has repeatedly prepared the dih drobromide from dextrogyrate limonene, dipentene, terpinhydrate,[43] als from terpinolene.[44]

Properties.

In its properties the bromide resembles the chloride. Melting point 64°. (Hell & Ritter[16] 42°.)

Methods of Formation.

These are analogous to those of the chloride. In how far they have been carried out can be seen from the historical sketch.

Preparation.

Dipentene dihydrobromide can be prepared in few minutes when to a solution of limonene or dipentene an excess of a saturated solution of hydrobromic acid is added. The mixture must be left cold, and when poured into water the dihydrobromide is precipitated in pure condition.[45].

Dipentene Dihydriodide.

Zweifach jodwasserstoffsaures Terpilen — Oppenheim.[14] 1862.
Cynen-Dihydrojodid — Hell und Ritter.[16] 1884.
Dipenten-Dihydrojodid — Wallach.[17] 1887.

History.

Wiggers[46] and also List[10] did not succeed in preparing a hydriodide analogous to the hydrochloride. Oppenheim was the first to succeed. He obtained it by treating terpin hydrate with phosphorus iodide. The product, however, cannot have been pure as indicated by the melting point 48°. Hell & Ritter[16] (1884) obtained the hydriodide analogous to the hydrochloride and hydromide from cineol. Melting point 76–77°. At the same time and independently Wallach and Brass[47] obtained the same compound from the same material. Wallach also prepared it from terpin-hydrate[48] and terpineol[49] with the aid of hydriodic acid.

Properties.

In its properties the dihydriodide is analogous to the dihydrochloride and dihydrobromide, but it is less stable. However with its purity its stability increases. From petroleum ether it crystallizes in two physically isomorphous modifications[50]: rhombic crystals melting at 77° and monosymmetric crystals melting at 78–79°.

Methods of Formation:

These are analogous to those above mentioned. In how far they have been carried out can readily be seen from the historical notes.

Preparation:

1. Analogous to that of the hydrobromide.

2. From terpin hydrate: to 5 g. terpin hydrate contained in a fla about 20 cbcm. of conc. hydriodic acid (spec. grav. 1.96) are added and t mixture is shaken without the application of heat. The transformati into the iodide takes place quantitavely. The drained product is cry tallized from petroleumether in which terpin hydrate is almost ins uble.[51]

THE HYDRATES OF THE LIMONENE GROUP.

Terpin and Terpin-hydrate.

Synonyms.

Pyrocamphorium[1] — Trautwein.
Terpenthin salz[1] — Buchner,[2] 1820.
Terpentinölcamphorid[1] — Trommsdorf,[3] 1828.
Terpin[1] — Berzelius,[4] List,[5]&[6] 1848.
Trihydrate d'essence de térébenthine[1] — Deville.
Turpentine camphor[1] (C^{40} C^{20} O^{4}).
Hydrate of oil of turpentine.[1]
*Terpenthincampher — Blanchet and Sell,[7] 1833.
*Wachholderbeerenölhydrat } Blanchet and Sell,[7] 1833.
*Terpenthinhydrat }
Terpenthincampher — Wiggers,[8] 1840.
Terpentinölhydrat,[9] 1884.
Hydrate de térébenthine } Deville,[10] 1849.
Bihydrate d'essence de térébenthine }
Terpinhydrat — Wallach.[11]

History.

Disregarding the dehydration products the chemical literature of te pin, resp. of terpin hydrate at first sight appears to be very simple. A cording to Gmelin[1] terpin hydrate was observed as early as 1827, b Geoffroy; Buchner[2] is stated to have regarded it as a salt of succini acid with a volatile base, whereas Dumas and Peligot[12] and then Wigger considered it to be a hydrate of turpentine oil. It is rather strange tha Blanchet and Sell[7] are not mentioned by Gmelin in his historical r view. The same views, however, have been expressed before, viz by Blanchet and Sell,[13] by the publishers of the "Annalen de Chemie und Pharmacie," and by List. They are the same we find in ou

* Those marked with *, no doubt, pertain not to terpin or its hydrate but to pinol hydrat which was not recognized as such at the time.

hand-books to-day. A critical study, however, must throw doubt upon at least some of their statements. Unfortunately time does not permit at present to verify these doubts by experimental evidence. Nevertheless, the same, as well as the reasons therefore, shall be mentioned. If Blanchet and Sell's contribution[13] be read in the light of our present knowledge of terpin hydrate several points will have to be regarded in a rather doubtful light. The same is true of the historical sketch given by the editors of the "Annalen." It is even stranger that List could make the remark that the older analytical results correspond, whereas they fall very distinctly into two categories. An explanation for their views is probably to be found in the fact that at an early date terpin hydrate was converted into terpin free from water of crystallization, and that pinol hydrate, a substance approaching terpin closely in empirical composition had not been recognized as such. To make physical differences agree or to regard such differing statements as misprints may be admitted a single time, a repetition of such a procedure, however, must create suspicion. An attempt to bring all statements concerning the so-called "terpentine oil hydrate" in harmony with actual facts would leave a number of points unexplained. This riddle, however, may be solved by substituting pinol hydrate in place of terpin (free from water of crystallization) whenever necessary. The following table may, therefore; serve as a key to a better understanding of the terpin-literature.

$C_{10}H_{20}O_3$	$C_{10}H_{18}O_2$		Blanchet & Sell.	Dumas & Peligot.			Sten-house.		Wiggers.		Sobrero.
69.76	70.58	C	70.91	....	....	....	69.99	70.30	.....	.....	70.58
11.62	10.58	H	11.05	....	....	....	11.68	11.62	.....	.....	10.58
$C_{10}H_{22}O_3$	63.15	C	....	*a.* 63.8	*b.* 63.8	*c.* 64.0	.....	.....	63.315	63.25	.....
	11.57	H	....	11.4	11.5	11.4	.....	.....	11.555	11.56	.....
Melting point....		....	150°	....	....	....	150°		.....	.....	*

* Armstrong has shown recently that pinol hydrate prepared according to Sobrero melts at 150° (J. C. S., June, 1891, J. 317.)

Properties.

Terpin hydrate crystallizes in large transparent prisms.[17] It is so ble in 250 p. of water, 10 p. alcohol, 100 p. ether, 200 p. chloroform; in 32 of boiling water and 2 p. of hot alcohol;[18] it is insoluble in petroleu ether. It melts at 116-117°, sublimating at the same time. When heat in a flask the water of crystallization is first given off with which a po tion of the substance passes over, then the anhydrous terpin distills 258°. The anhydrous terpin congeals to a hard crystalline mass whi melts at 102-105°.[20]

Terpin and its hydrate are saturated compounds [19] when boiled wit acids or other dehydrating agents there results first of all the monatom unsaturated alcohol tepineol, $C_{10}H_{18}$. Further dehydration yields a cording to the conditions and dehydrating agent employed, three hydr carbons $C_{10}H_{16}$ differing essentially in their properties: terpinen terpinolene and dipentene.[21] Cineol also results, but only in sma quantities[22] When treated with the hydrohalogen acids dipenter dihydrochloride,[23] dihydrobromide[24] and dihydriodide[25] result respe tively. When treated with the chlorine, bromineand iodine derivative of phosphorous the same dipentene derivatives result.[26] Hydrofluori acids also acts upon terpin hydrate but the resulting products have no been studied[27]. With nitric acid it appears to yield an ether from whic upon saponification the alchol can be regenerated only in part.[28] Nitri acid[29] also oxidizes terpin hydrate; permanganate solution[30] even mor readily.

Occurrence.

In some text-books it has been stated that terpin hydrate has bee found in the oil from Acimum basilicum, L., and in Cardamom oil. Thi however, is not at all to be considered as a natural occurrence. To ou knowledge terpin hydrate does not occur in plant organs.

Determination.

Characteristic for terpin hydrate are its crystalline form and its melt ing point, as also the melting-point of the anhydrous terpin. Chemicall it can be characterized by converting it into any one of the dipentene hydrohalogen derivatives. Of these the di-hydriodide can be prepare most readily.[31]

Methods of Formation.

Hydration of—

1. The hydrocarbons $C_{10}H_{16}$:
   (a) Limonene.[32]
   (b) Pinene [33] (whereby inversion takes place.)

II. The alcohol terpineol [34] $C_{10}H_{18}O$. As an indirect formatior that from limonene monhydrochloride [35] may be considered under terpineol.

Preparation.[36]

According to Hempel, who compared the methods of Wiggers and Deville, 8p. of turpentine oil are mixed with 2p. nitric acid (spec. gravity 1.25—1.3) and 2p. alcohol. The mixture is shaken several times daily until crystals begin to form. To obtain crystals in comparatively short time shallow dishes can be employed. The drained crystals are re-crystallized form alcohol.

Terpineol.

Synonyms:

Terpineol[1] — List[2] 1848.
Berthelot[3] 1852.
Oppenheim[4] 1864.
Tilden[5] 1878.
Tanret[6] 1885.
Diterebenhydrat — Oppenheim[4] 1864.
Terpinhydrat — Flawitzky[7] 1879 and 1887.
Monohydrate de Térébenthène — Tanret[6] 1885.
Terpineol — Wallach[8] 1885.
Terpilenol, Terpol } Bouchardat and Voiry[9] 1887.

History:

In an impure form, as so-called "terpinol," terpineol has given rise to manifold speculations, which need not be considered here. Both Tilden[5] and Flawitzky,[7] according to opposite methods, obtained relatively pure terpineol, but it was Wallach who first introduced order into the chaos of older speculations. By means of a systematic study of the dehydration products of terpin, in which all side reactions were avoided as much as possible he ascertained that terpineol is the first dehydration product of terpin, and that by further dehydration it is converted, according to conditions, and reagents into one or more of three hydrocarbons, viz., dipentene, terpinene, terpinolene; also that in the process of dehydration of terpin small quantities of cineol are formed as byproduct. These few introductory remarks will enable us to interpret the older literature upon this subject.

In 1846 Wiggers[10] obtained from terpin hydrate by heating the same with hydriodic acid a compound to which he assigns the formula $C^{20}H^{16} + \dot{H}$. The results of his analyses do not at all agree well with this formula. He remarks that this substance might be regarded as the "Oxyd von einem aus dem Terpentinöl neuentstandenen Radical = $C^{20}H$,[17] wozu, aber, wie es scheint durchaus kein Grund vorhanden ist."

In 1848 List[2] supposes to have obtained the same substance Wiggers had in hands by boiling terpin with acidulated water (one drop of conc. sulphuric acid sufficed to decompose 11.5 g terpin). The substance termed "Terpinol" by him is stated to possess a hyacinth-like odor, especially when largely diluted and to boil *constantly* at 180°. When saturated with hydrogen chloride it yields the same chloride as does terpin hydrate. (Dipentene dihydrochloride.) This fact, List supposes, supports Berzelius' view (27, Jahresbericht, p. 445,) that terpinol is the oxide of a radical $C^{20} H_{17}$ and that terpin is the hydrate of terpinol. The following formulæ are to express "die verschiedenen Betrachtsungsweisen der Constitution dieser Körper:"

Crystallized Terpin:—

$$C^{20} H^{22} O^{6} = C^{20} H^{16} + 6\dot{H} = C^{20} H^{17} O + 3 \dot{H} + 2aq.$$

Anhydrous Terpin:—

$$C^{20} H^{20} O^{4} = C^{20} H^{16} + 4\dot{H} = C^{20} H^{17} O + 3\dot{H}.$$

Terpinol:—

$$C^{20} H^{17} O = C^{20} H^{16} + \dot{H} = C^{20} H^{17} O.$$

"Chlorwasserstoff Terpin":—

$$C^{20} H^{18} Cl^{2} = C^{20} H^{16} + 2H Cl = C^{20} H^{17} Cl + H Cl.$$

However, these views do not satisfy List, for "es erheben sich dagegen alle die Umstäde, welche gegen die Annahme sprechen, das der Alchohol das Hydrat der Aethers und dieser das basische Oxyd von $C^{4} H^{5}$ sey."

According to Oppenheim[4] (p. 155) Berthelot[3] (1852) is stated to have obtained "terpinol" "bei der Einwirkung von Kali auf die zweifach chlorwasserstoffsaure Verbindung des Terpilens." He accepts the formula "$C_{20} H_{16}$, HO."

Oppenheim[4] (1864) claims to have obtained "das Terpinol von Wiggers und List" by treating "zweifachbromwasserstoffsaures Terpilen" with acetate of silver: $2C_{10}H_{18}Br_2 + 4C_2H_3 AgO_2 = 4Ag Br + \left.\begin{matrix} C_2 H_3 O \\ C_2 H_3 O \end{matrix}\right\} O + 2C_2 H_4 O_2 + C_{20} H_{34} O$. This "terpinol" boiled between 165–208°. Oppenheim acknowledges that *he could never obtain a product of constant boiling point;* also that Gerhardt doubted the existence of such a substance. As an "Aether des Terpins" Oppenheim designates a substance which very likely was impure acetate of terpineol. (p. 157.)

By boiling terpinhydrate with water acidulated with hydrochloric acid Tilden[5] (1878) obtained a substance $C_{10} H_{18} O$, resp. $C_{10} H_{16}. H_2 O$ to which he assigns the double formula $C_{10} H_{18} <^{O}_{O}> C_{10} H_{18}$. He retains for it the term terpinol and supposes it to be an ether or anhydride of terpin, i. e. to stand in the same relation to terpin as ether does to alcohol. "Almost conclusive evidence of this is supplied by the

action of hydrochloric acid, which does not give a monochloride as might be expected if terpinol had the constitution expressed by $C_{10}H_{17}(OH)$."

In the following year, however, a vapor density determination compels Tilden to accept the simple formula $C_{10}H_{18}O$. "It is somewhat remarkable that this chloride (i. e. dipentene dihydrochloride) thus formed from terpinol, corresponds in constitution not with that substance but with terpin.

$$C_{10}H_{18}\begin{cases}Cl\\Cl\end{cases} \qquad C_{10}H_{18}\begin{cases}OH\\OH\end{cases}$$

although when decomposed by alkalis it yields terpinol and not terpin."

Tanret[6] (1885) states that the formula $(C_{20}H_{16})_2H_2O_2$ for terpinol ought to be rejected, that terpinol proper boils between 215–220° and is a monohydrate of terebenthene $(C_{20}H_{16}{}'H_2O_2$; also that the product which results from the action of dilute acids upon the terpin, or of alcoholic potassa upon "Terebenthen dichlorhydrat" are but mixtures of a hydrocarbon $C_{20}H_{16}$ with monohydrate.

Since we shall have occasion to refer repeatedly to Wallach's[8] (1885) researches on terpineol it may suffice here to mention the results of his dehydration experiments, which, as has already been mentioned served as a key to a better understanding of this part of the limonene literature. Hydrochloric and nitric acids were not employed as dehydrating agents on account of the byproducts to which they give rise: hydrochloric acid to chlorides, nitric acid to oxidation products. The products resulting upon treatment of terpin hydrate with

sulphuric acid (1:2) are	terpinene. terpinolene. terpineol.
sulphuric acid (1:7)	terpinene (largely).
phosphoric acid [spec. gr. 1.12=20 p. c.] (1:4):	terpineol and terpinene or dipentene.
phosphoric acid [spec. gr. 1.12 = 20 p. c.] (1:2):	terpineol (exclusively).
glacial acetic acid	terpineol (essentially).
potassium bisulphate:	terpineol. dipentene.

Terpineol always results as intermediate product and upon further dehydration is converted into one or more of the above mentioned terpenes. "*Bei der Zerlegung des Terpinhydrats durch Säuren od. durch wasserentziehende Mittel ensteht unter keiner Bedingung eine Verbindung von der Zusammensetzung $C_{20}H_{34}O$ und dem Siedepunkt 168°.*

Thus far the terpineol under consideration, whether pure or impure as "terpinol," always showed itself to be optically inactive.

Bouchardat and Lafont[11] report (1886) on a series of experiments pertaining to the action of acids on the terpenes. The action of acetic acid on pinene furnishes a mixture of acetates which can be separated by means of fractional distillation under diminished pressure. The separated acetates yield upon treatment with alcoholic potassa optically active terpineol and borneol respectively. Whereas, by this treatment pinene could be converted into terpineol and borneol, camphene could be converted into borneol only, dipentene into optically inactive terpineol, dextrogyrate limonene[12] into dextrogyrate terpineol. From the o-terpineol they obtained crystals at a very low temperature.

With the introduction of new terms, viz.: "terpilenol" and "terpol" for terpineol, and of "terpal" for cineol Bouchardat and Voiry[9] (1887) have rendered poor service to science. Their disregard of the results achieved by others certainly is not honorable.

Flawitzky[1] $\left\{\begin{matrix}1879\\1887\end{matrix}\right\}$ prepared optically active monohydrates, which he termed "Terpenhydrate," by treating dextro—and lævogyrate pinene with alcoholic sulphuric acid. No doubt, these terpenehydrates as well as the "terpilenoles" of Bouchardat are optically active terpineols inactivated more or less by the presence of optically inactive terpineol. When dehydrated with acetic acid anhydride they yielded optically active hydrocarbons $C_{10}H_{16}$ which Flawitzky termed "Isoterpene" and which, to judge by their properties were more or less impure limonenes.

Properties.

Terpineol is a viscid[13] liquid[13] of agreable odor,[14] lighter than and insoluble in water, readily soluble in alcohol. It is volatile with water vapors and boils between 215–218° [15]. That obtained from dipentene and and terpin is optically inactive,[6] that obtained from optically active pinene and limonene is optically active.[17]

Terpineol is an unsaturated compound.[19] The addition of water converts it into terpin and its hydrate.[20] The removal of a molecule of water dehyrates it according to reagents and conditions to dipentene,[21] terpinene or terpinolene,[22] but never to pinene. The hydrohalologen acids convert terpineol like terpin into the dihydrohalogen addition products of dipentene i. e. the dihalogen esters of the diatomic alcohol but not into a monohalogen ester of the monatomic alcohol terpineol[23], probably according to the equation.[24]

$$C_{10}H_{17}OH + HCl = C_{10}H_{18}\left\{\begin{matrix}Cl\\OH\end{matrix}\right.$$

$$C_{10}H_{18}\left\{\begin{matrix}Cl\\OH\end{matrix}\right. + HCl = C_{10}H_{18}Cl_2 + H_2O.$$

The monohydrochlorides of the limonenes, no doubt are to be regarded as monochlorine esters of the terpineols.[25] Apparently the acetic ester can be prepared from the alcohol.[26] When saponinfied with alcoholic

potassa thes esters yield the corresponding terpineols.[11-12] Presumably nitric and sulphuric acids are capable of forming similar compounds, which, however, are very unstable. The presence of water at a normal temperature suffices to sapoinfy them.[27] Phosphoric acid converts terpineol into the isomeric cineol.[28] With carbanil terpineol yields a crystallizable phenyl-terpinyl-urethane, which sufficiently demonstrates the alcoholic nature of the same.[29] Apparently the hydroxy hydrogen can be replaced by sodium.[30] Whereas very dilute nitric acid causes the formation of terpin hydrate more concentrated acid oxidizes. Potassium permanganate also readily oxidizes terpineol.[31]

Methods of Formation.

I Hydration of
- Pinene.
- Limonene and Dipentene.

II Dehydration of
- Terpin, resp. terpin hydrate.

III Saponification of
1. The acetates of the terpineols.
2. The dihalogen esters of terpin.

Preparation.

To prepare optically inactive terpineol 25 g. of terpin hydrate are boiled with 50 cbcm. of phosphoric acid, specific gravity 1.12 [= 20 per cent.] for 10 or 15 minutes, or 50 g. of terpin hydrate are boiled in a flask attached to a reflux condenser with 100 cbcm. glacial acetic acid for five or six hours. The resulting products are distilled with water vapor. The dried oil is rectified and the fraction boiling between 215–218° is collected[8]. The optically active terpineols can be obtained according to Flawitzky[7] by hydration of the pinenes by means of alcoholic sulphuric acid, or according to Bouchardat and Lafont[11&12] by saponification of the acetic esters (obtained from the optically active pinenes or limonenes) by means of alcoholic potassa.

Occurrence and Identification.

Thus far the analysis and boiling point of terpineol and the conversion into dipentene dihydrochloride have served as factors for its identification. Whether these data are sufficient is rather questionable. If possible the carbanil reaction should be employed. If the latter be taken as the only true criterion the presence of terpineol in natural products has not yet been absolutely proven. However, the occurrence of terpineol in a number of volatile oils is very probable.

Nitrosochlorides, Nitrosates, Nitrolamines.

History:

According to Wallach[2] Bunge was the first to prepare a nitrosyl chl ide derivative of a terpene. Tilden,[3] however, was the first who examin it more carefully and described it. Thus he obtained from the class "terpenes" (pinene) an optically inactive nitroso chloride which melt at 103°, and which, by splitting off hydrogen chloride was converted in the characteristic nitroso terpene, melting at 129°. From the class "citrenes" (limonene) he obtained an isomeric, optically active nitro chloride, which, by splitting off hydrogen chloride, was converted into nitroso derivative ("nitroso herperidene") isomeric with "nitroso te pene," and whose melting point was 70–71°. These reactions hencefor characterized Gladstone's[4] "terpenes" and "citrenes," and the identi of herperidene, carvene and citrene could no longer be doubted. T den's method of preparing the nitroso chlorides by passing nitros chloride into a solution of terpene, however, was very defective. Neith did Tilden surmise that his "herperidene nitrosyl chloride" was a mi ture.

In 1885 Goldschmidt[5] showed that the oxime from carvol was che ically identical with "nitroso herperidene" of Tilden. Soon after (188 Wallach[6] taught how to prepare the nitroso chlorides in large quan ties with the aid of hydrochloric acid and amylnitrite, also the prepa ation of the nitrolamines. Fully as important was the discovery th the nitroso chlorides were mixtures and that they could be separat into the α and β compounds (1889).[7]

Preparation.

Wallach's method of preparation is as follows: "To 5 cbcm. of lim nene, 7 cbcm. of amyl nitrite (or 11 cbcm. of ethyl nitrite) and 12 cbc of glacial acetic acid are added, and to this solution, kept cold in freezing mixture, a solution of 6 cbcm. of crude muriatic acid in 6 cbc of glacial acetic acid is carefully added in small quantities. Finally cbcm. of alcohol are added." The great solubility of the α-- and t sparing solubility of the β— compound admit of an easy separation the two nitroso-chlorides.

Physical Properties.

α-Nitrosochlorides.

The limonene α-nitroso-chlorides crystallize in tabular crystals the monoclinic system[9]. The dipentene derivative does not crystalli as well[10]. The + and $-\alpha$-nitroso-chloride melt at 103—104°, where the dipentene derivative melts at 78°[11], but congeals to a crystalline ma immediately after, and melts a second time at 103–104°. The limone derivatives are soluble in about an equal weight of chloroform and twi

their weight of ether. These solutions are strongly optically active $[\alpha]_D = +313.4°$ resp. $-314.8°$ [13]. The dipentene derivative is more readily soluble, and is optically inactive.

β-Nitrosochlorides.

The limonene β-nitrosochlorides are precipitated from their chloroform solutions with methyl alcohol as woolly crystalline needles.[14] By careful crystallization from chloroform they can be obtained in handsome prismatic crystals.[15] The β-nitrosochlorides are much less soluble than the α-derivatives. Their optical activity is also not as great: $[\alpha]_D = + 240.3°$ resp. $-242.2°$ [16] The melting point has been found to vary, viz., 100–106° [14] Dipentene β-nitrosochloride, like the α-derivative, is more soluble, does not crystallize as well as its optically active modifications and melts at 101°. A third modification which melts at 75–76° has been observed.[17]

Chemical Properties.

The chemical properties of the α- and β-nitrosochlorides do not differ essentially and can, therefore, be considered together. When carefully heated by themselves (Tilden [3]), or when heated with alcoholic potassa (Wallach[18]) hydrogen chloride is split off and carvoximes result (Comp. also Goldschmidt [6]). Thus dextrogyrate limonene-nitrosochloride yields laevogyrate carvoxime, also obtainable from laevogyrate carvol; whereas laevogyrate limonene nitrosocloride yields dextrogyrate carvoxime, also obtainable from dextrogyrate carvol.[19] From dipentene nitrosochloride optically inactive carvoxime results, which can also be obtained by mixing solutions of equal parts of the optically active carvoximes.[20]

A molecule of hydrogenchloride can be added to form nitrosochloride-hydrochlorides, but these differ from the hydrochlor-nitrosochlorides.[21] The chlorine of the $\left\{\begin{matrix}NO\\Cl\end{matrix}\right.$ group can easily be replaced by basic radicles whereby nitrolamine bases result. In these double decompositions α- and β-nitrosochloride behave alike.[22]

The nitrosochlorides are unsaturated. With bromine they yield an unstable dibromide (Tilden [1]). Their unsaturated condition is also recognizable from the *hydrochlor* nitrosochloride.

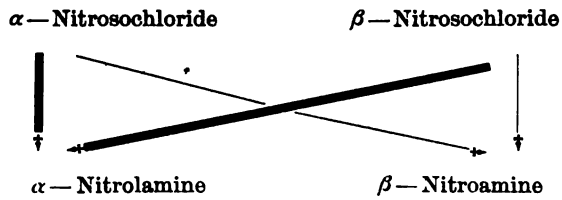
Nitrosates.

Thus far dipentene-nitrosate only has been described. There appears to be some difficulty connected with the preparation of the limonene-nitrosates.[23] Dipentene-nitrosate crystallizes in laminæ which melt at 84°. In its constitution it is analogous to the nitrosochloride; by splitting off nitric acid o-carvoxime results; by double decomposition with bases the optically inactive nitrolamine base results; apparently it adds

a molecule of hydrogenchloride (molecular addition); its unsaturated condition becomes apparent from the hydrochlor nitrosate. Thus far a separation of two nitrosates, if such a mixture results at all, has not been effected.

Nitrolamines.

The double decomposition of terpinene nitrosite with bases on the part of Wallach induced this investigator to study the behavior of nitrosochlorides and nitrosates toward bases. Thereby the analogy between the nitrosochlorides $\begin{cases} \text{No} \\ \text{Cl,} \end{cases}$ nitrosites $\begin{cases} \text{No} \\ \text{O (NO)} \end{cases}$ and nitrosates $\begin{cases} \text{NO} \\ \text{O (NO}_2\text{)} \end{cases}$ was established. The application of this reaction proved especially favorable in the limonene group. Even before the nitrosochlorides were known to be a mixture the notrolanilids were recognized as such. Furthermore, it was ascertained that the separated α and β nitrosochlorides yielded each two, viz, an α and a β nitrolamine base, and that these α and β nitrolamine were respectively identical. The reactions may be expressed in the following manner:



α-Nitrolpiperidine[26]. $C_{10}H_{16}\begin{cases} \text{NO} \\ \text{N. } C_5H_{10} \end{cases}$

Limonene-α-nitrol piperidine crystallizes from alcohol in handsome rhombic crystals which melt at 93–94°. In petroleum ether, in ether and chloroform it is readily soluble, less so in alcohol. The solutions turn the plane of polarized light in the direction of the underlying hydrocarbons: $[\alpha]_D = +67,75°$ resp. $-67,60°$. The hydrochlorides turn the plane of polarization in the opposite direction.

The *dipentene base* precipitates upon the mixture of the petroleum ether solutions of the optically active components. From alcohol it crystallizes in monosymmetric crystals which stand in no relation to the well formed crystals of its optically active modifications.

β- Nitrolpiperidine[26] $C_{10}H_{16}\begin{cases} \text{NO} \\ \text{N. } C_5H_{10}. \end{cases}$

The *Limonene* derivatives melt at 110–111°, crystallize monosymmetrically, and are less soluble, especially in petroleum ether, than the

-compounds. The solutions turn the plane of polarized light in a direction opposite to that of the underlying hydrocarbon:

dextrogyrate-limonene-β-nitrolpiperidine $[\alpha]_D = -60,37°$.

lævogyrate " " " " $[\alpha]_D = +60,18°$.

Their hydrochlorides are almost optically inactive. The *dipentene* base stands in similar relation to its components as does the α-base to its. It melts at 152°.

$$\alpha\text{-Nitrol benzylamine}^{27}\ C_{10}H_{16}\begin{cases} NO. \\ NH\,CH_2\,C_6H_5. \end{cases}$$

The *limonene* α-nitrol benzylamine crystallizes from alcohol in hard needles which possess no sharply defined crystal faces. It melts at 93°. It is optically strongly active turning the plane of polarized light in the same direction with the underlying hydrocarbon; $[\alpha]_D = +163.8°$, resp. $-163.6°$. The salts of this base are sparingly soluble in water, more readily in alcohol. Their rotatory power is without exception opposite to that of the free base.

dextrogyrate-limonone α-nitrol benzylamine-chlorhydrate $[\alpha]_D = -82.26°$.

lævogyrate-limonone α-nitrol benzylamide-chlorhydrate $[\alpha]_D = +83.06°$.

dextrogyrate-limonene α-nitrol benzylamine-nitrate $[\alpha]_D = -81.5°$.

lævogyrate-limonene α-nitrol benzylamine-nitrate $[\alpha]_D = +81.0°$.

dextrogyrate-limonene α-nitrol benzylamine-d-tartrate $[\alpha]_D = -49.98°$.

lævogyrate-limonene α-nitrol benzylamine-d-tartrate $[\alpha]_D = +69.6°$.

dextrogyrate-limonene α-nitrol benzylamine-l-tartrate $[\alpha]_D = -69.9°$.

lævogyrate-limonene α-nitrol benzylamine-l-tartrate $[\alpha]_D = +51.0°$.

The *β-Nitrol benzylamines* have not yet been obtained in a pure condition.

$$\alpha\text{-}Nitrol\ anilids^{28}\ C_{10}H_{16}\begin{cases} NO \\ NHC_6H_5 \end{cases}$$

The *limonene* derivatives crystallize, when pure, from dilute alcohol in hard, colorless, tabular crystals which melt at 112–113°. Their action upon polarized light corresponds to that of the underlying hydrocarbons, viz.: $[\alpha]_D = +102.25°$ resp. $-102.62°$. The hydrochlorides are sparingly soluble in water, more readily in alcohol. Their solutions deviate the ray of polarized light but little, however, in the same direction as do the free bases.

The *α-Nitroso-derivatives*,[29] $C_{10}H_{16}\begin{cases}NO\\N(NO)C_6H_5,\end{cases}$ crystallize in white blunt needles and melt at 142°. Their solutions deviate the ray of polarized light in the direction as do the underlying bases, but the action is lessened, viz.: $[\alpha]_D = +46.20°$ resp. $-47.82°$

Dipentene-α-nitrolanilid crystallizes from a mixture of alcoholic solutions of equal parts of the limonene derivatives and melts at 125-126°.

The *dipentene nitroso-compound*[29] is obtained in the same way from its components. It is less soluble than the latter, crystallizes better, i. e., in triangular tablets and melts at 147°.

The *Nitrolanilids*, like the nitroso-chlorides, are unsaturated compounds and can take up a molecule of hydrogen chloride. The α-hydrochlor addition products, $C_{10}H_{17}Cl\begin{cases}NO\\NH.C_6H_5\end{cases}$ are identical with the hydrochlor nitrol anilids to be described later.

β-Nitrolanilids[28] $C_{10}H_{16}\begin{cases}NO\\NH.C_6H_5.\end{cases}$

The limonene β-nitrolanilids are somewhat filty needles, which are almost insoluble in water and petroleum ether, readily soluble in hot benzol, but difficultly in cold benzol and in ether, more readily soluble in alcohol and chloroform. Whereas the solutions of the β-compounds are not precipitated. The latter thus appear to be stronger bases. Melting-point 152°. Optically they act in a direction opposite to that of the underlying hydrocarbons and thus differ from the β-derivatives.

dextrogyrate-limonene β-nitrolanilid $[\alpha]_D = -89.39°$.

lævagyrate-limonene β-nitrolanilid $[\alpha]_D = +87.17°$.

Their *nitroso-derivatives*[29], however, which melt at 136° again turn the plane of polarized light corresponding in direction to that of the underlying hydrocarbon. Their specific rotatory power is by (about) 10° stronger than that of the corresponding α derivatives:

dextrogyrate-β-nitrol-nitroso-anilid $[\alpha]_D = +57{,}67°$

laevogyrate-β-nitrol-nitroso-anilid $[\alpha]_D = -57{,}75°$

Dipentene β nitrol nitroso anilid, obtained from its optically active components, does not crystallize well and melts at 129°.

The *β-hydrochlor addition products*[30] differ from the α-compounds and have thus far not been obtained from the hydrochlor-nitrosochlorides.

The *limonene* derivatives crystallize from alcohol in beautiful, hexagonal tablets and melt at 78°. They are not at all strongly optically active, but turn the plane in a direction corresponding to that of the underlying hydrocarbons. $[\alpha]_D = +12.91°$ resp. $-12.51°$. The hydrochlor addition product of *Dipentene-β-nitrol-anilid* crystallizes from its alcoholic solution in four sided prisms and melts at 90°.

Hydrochlor, Nitrosochlorides, Nitrosates and Nitrolamines.

Through the action of hydrochloric acid, amyl nitrite and nitric acid upon "carvene" Maissen obtained a "compound $C_{10}H_{16}\left\{\begin{matrix}NO\ Cl\\NO_3\ H\end{matrix}\right.$" which Wallach recognized as hydrochlornitrosate, $C_{10}H_{17}Cl.NO(O.NO_2)$. Later it was shown that this compound was a dipentene and not a limonene ("carvene") derivative. The corresponding hydrochlor-nitrosochloride was first prepared by Wallach. The optically active modifications were prepared by me in Prof. Wallach's laboratory.

The hydrochlor-nitrosochlorides, etc., are saturated compounds. They can be regarded as nitrosochlorides, nitrosates and nitrolamines of the monhydrochlorides of the limonene hydrocarbons. Thus far all of the saturated nitrosochlorides, etc., prepared from *monhydrochlor limonene*, have been obtained in but one modification, which corresponds to the α-modification of the unsaturated derivatives free from chlorine.

Hydrochlor nitrosochlorides[31] $C_{10}H_{17}Cl\left\{\begin{matrix}NO\\Cl\end{matrix}\right.$

The limonene derivatives crystallize poorly, melt at 92-93° without decomposition. $[\alpha]_D$ for the dextrogyrate compound $= +173.71°$. The crude product is largely contaminated by the dipentene modification. The latter apparently posseses a higher melting point, viz, 109°. Like the unsaturated nitrosochlorides they split off hydrochloric acid, however, to form hydrochlorcarvoximes.

Hydrochlor-nitrosates[32] $C_{10}H_{17}Cl\left\{\begin{matrix}NO\\O(NO_2)\end{matrix}\right.$

The *limonene* derivatives can be obtained in handsome pearly prisms. They melt at 108° decomposing at the same time. $[\alpha]_D$ for the dextrogyrate compound $= +61.34°$. The *dipentene* hydrochlor-nitosrate also melts at 108-109° and is readily distinguished by its optical activity. From it a molecule of nitric acid can be split of with the aid of dimethylanilin[33] anologous to the hydrochlor carvoxime reaction. The resulting

product crystallizes from an ethyl-alcoholic solution with a molecule of $C_2 H_5 O H$, from a methyl-alcholic solution wit a molecule of $C H_3 O H$.

Hydrochlor-nitrolbenzylamine,[34] $C_{10} H_{17} Cl \begin{cases} NO \\ NH. CH_2 C_6 H_5 \end{cases}$

The *limonene*-derivatives were obtained in white filty needles, which melt at 103–104.° They turn the plane of polarized light as do the underlying hydrocarbons: $[\alpha]_D = +149.6°$ resp. $-147.4.°$

The chlorhydrates crystallize from alcohol in small needles which melt and decompose at 163–164.° The action upon polarized light corresponds to that of the free bases though weakened: $[\alpha]_D = +46.97°$ resp. $-50.9.°$

The *dipentene-hydrochlor-nitrol-benzylamine* crstallizes better than its optically active components, melts at 150° and is but difficultly soluble. Its hydrochlorate, however, is more soluble than its components, but possesses the same melting point.

Hydrochlor-nitrolanilids,[35] $C_{10} H_{17} Cl \begin{cases} NO \\ NH. C_6 H_5 \end{cases}$

The limonene-derivatives crystallize from ether in handsome colorless flat prisms. Melting point 117–118° $[\alpha]_D = +126.95,°$ resp. $-122.34.°$

Dipentene-hydrochlor-nitrolanilid, prepared synthetically is colorless and melts at 140–141.° When hydrogen-chloride is split off α- and β- nitrol anilids apparently result.[36]

REFERENCES.

Dextrogyrate Limonene:

[1] Ann. Chim. Phys. T. 52.
[2] Annalen, Bd. 6, p. 259.
[3] J. Pharm, T. 26, p. 1.
[4] J. pr. Chem. Bd. 24, p. 257.
[5] Ann. Chim. Phys. [3] T. 37.
[6] Ibidem, T. 38.
[7] Ibidem, T. 39.
[8] Annalen, Bd. 35, p. 308.
[9] Ibidem, Bd. 85, p. 246.
[10] J. C. S., Vol. 17, p. 1.
[11] Ibidem, Vol. 24, p. 1186.
[12] Ibidem, Vol. 31, p. 549.
[13] Berichte, Bd. 6, p. 915.
[14] Ibidem, Bd. 5, p. 94.
[15] Ibidem, (1874) p. 627.
[16] J. C. S., 1877, Vol. 1, p. 554.
[17] Annalen, Bd. 225, p. 311.
[18] Ibidem, p. 318.
[19] Ibidem, Bd. 227, p. 290 and 291.
[20] Ibidem, p. 277.
[21] Ibidem, p. 289.
[22] Ibidem, Bd. 246, p. 222.

Lævogyrate Limonene.

[1] Ann. Chim. Phys. [3] T. 37, p. 80.
[2] Annalen, Bd. 227, p. 287.
[3] J. C. S., Vol. 47, p. 779.
[4] Annalen, Bd. 246, p. 222.
[5] Dissertation, p. 16.

Dipentine.

[1] Ann. Chim. Phys. T. 52.
[2] Annalen, Bd. 6, p. 259.
[3] Ibidem, Bd. 27, p. 40.
[4] J. Pharm., T. 26, p. 1.
[5] J. pr. Chem., Bd. 24, p. 257.
[6] Annalen, Bd. 89, p. 358.

[7] Jahresber. f. Chem. f. 1854, p. 591 (Zeitschr. Pharm. 1854 pp. 3, 17, 65, 180.) Jahresber. f. Chem. f. 1855, p. 655 (Zeitschr. Pharm. 1855, pp. 2, 33, etc.)

[8] Royal Society of London Proceedings, vol. 10, p. 516.

[9] Bericihte, Bd. 5, p. 677.

[10] Compt. rend. T. 79, p. 223.

[11] Ibidem, T. 102, p. 50.

[12] Chem. News, vol. 46, p. 120.

[13] J. S. C., vol. 49, p. 316.

[14] Graebes "Cynen" is cymol, comp. also Wallach, Annalen, Bd. 225.

[15] Annalen, Bd. 225, p. 314.

[16] Ibidem, Bd. 227, p. 278.

[17] Ibidem, p. 301.

[18] Ann. Chim. Phys., T. 13, p. 259.

[19] Annalen, Bd. 67, p. 362.

[20] Ann. Chim. Phys. [3] T. 27, p. 80.

[21] J. C. S., vol. 49, p. 316.

[22] Compt. rend., T. 102, p. 50.

[23] Berichte, Bd. 12, p. 2354 and
Bd. 20, p. 1956.

[24] Compt. rend., T. 106, p. 663.

[25] Compare Ann. Bd. 252, p. 128.

[26] Compt. rend., T. 106, pp. 1419 and 1538.

[27] Annalen, Bd. 38, p. 111.

[28] ibidem Bd. 87, p. 312.

[29] Arch. d. Pharm., [2] Bd. 111, p. 104.

[30] Annalen, Bd. 128, p. 293.

[31] Berichte, Bd. 7, p. 1427.

[32] Berichte, Bd. 17, p. 1970, (sent in Aug. 14th, 1884.)

[33] Annalen, Bd. 192, p. 222.

[34] This view is confirmed by Wallach. But as Faust & Homeyer, in judging Voelckel's analyses (these are stated to agree better with cymol, $C_{10} H_{14}$) apparently did not consider that Voelckel had used $P_2 O_5$ in dehydrating cineol, so Hell & Stürcke overlook the fact that Faust & Homeyer employed $P_2 S_5$. Wallach has shown that phosphorus pentasulphide easily converts cynene (dipentene) into cymol.

[35] Berichte, Bd. 17, p. 1975. ("Eingelaufen am 14, Aug. 1884.")

[36] Annalen, Bd. 225, p. 291. ("Eingelaufen am 10, Aug. 1884.")

[37] Ibidem, p. 314 and [16] p. 317.

[38] Ibidem, Bd. 227, p. 277.

[39] Compare Annalen, Bd. 245, p. 197.

[40] Ibidem, Bd. 246, p. 221.

[41] Ibidem, p. 228.

[42] Ibidem, p. 230.

Properties, etc.

[1] Annalen, Bd. 227, p. 291 and 301.
[2] Ibidem, Bd. 252. p. 144.
[3] Ibidem, Bd. 246, p. 222.
[4] Dissertation, p. 38.
[5] Compare also F. Scheidt, "Ein Beitrag zur Kenntniss der Terpene Bonn, 1890.
[6] Annalen, Bd. 252, p. 145.
[7] Ibidem, Bd. 246, p. 224.
[8] Dissertation, p. 9.
[9] Berichte, Bd. 12, p. 2357 and
Ibidem, Bd. 20, p. 1956.
[10] Dissertation, p. 51.[1]
[11] Dipentene is always found as an impurity in artificial terpinene Annalen, Bd. 230, p. 261, and
Ibidem, Bd. 239, p. 38.
[12] Annalen, Bd. 230, pp. 247 and 262, and
Ididem, Bd. 239, pp. 2, 23 and 51.
[13] Oppenheim; Berichte, Bd. 6, p. 915, and
Ibidem, Bd. 7, p. 627.
Wright: J. C. S., vol. 21, p. 686.
[15] Only such data were considered that were deemed sufficient proof i. e. those in which optical properties are included.
[16] 1840 — Soubeiran & Capitain, J. d. Pharm., T. 26, p. 1. 1885 — Wallach, Annalen, Bd. 227, p. 290.
[17] 1840 — Soubeiran & Capitain[16]. 1877 — Tilden, J. C. S., Vol. I., p. 554. 1884 — Wallach — Annalen, Bd. 225, p. 318.
[18] 1854 — M. Berthelot, Ann. Chim. Phys. T. 40, p. —.
[19] 1857 — S. de Luca, Compt. rend., T. 45, p. 904.
[20] 1885 — Wallach, Annalen, Bd. 227, p. 290.
[21] Ibidem, p. 291.
[22] Ibidem, p. 292.
[23] Ibidem, p. 292.
[24] 1885 — Yoshida, J. C. S., Vol. 47, p. 787.
[25] 1888 — Wallach, Annalen, Bd. 246, p. 221.
[26] Annalen, Bd. 252, p. 109.
[27] Ibidem, p. 111.
[28] Ibidem, pp. 121 and 136.
[29] Ibidem, Bd. 227, p. 296.
[30] Ibidem, Bd. 238, p. 80.
[31] Ibidem, Bd. 252, p. 102.
[32] Ibidem, p. 101.
[33] Ibidem, Bd. 230, p. 224 and Bd. 239, p. 26.
[34] Ibidem. p. 246.

[35] J. C. S. ——

Eberhardt, Arch. d. Pharm., Bd. 225, p. 515.

[37] Wallach speaks of "aus Wurmsamenöl erhältlichem cynen," he obtained this "cynen" with the aid of chemical reagents, by n of which cineol is converted into dipentene. The hydrocarbon occu in these oils no doubt is dipentene, but the experimental proof is v ing. Comp. e. g. E. Jahns, "Ueber das Eucalyptol." Archiv d. Ph Bd. 223, p. 52.

[38] Method of preparation, Annalen, Bd. 239, p. 3.

[39] Ibidem, Bd. 252, pp. 127 and 136.

[40] Ibidem, Bd. 227, p. 295., Comp. Diisoprene of Bouchardat.

[41] [1] Comp. Wallach: "Am. Terpentinöl., Fichtennadelöl, Wachhol beerenöl, Macisöl, Salbeiöl, Citronenöl." Annalen, Bd. 227, p. 277 et

[2] (*a.*) That under certain conditions pinene will not form artif camphor but dipentene dihydrochloride was first shown by Berth (1852.) Comp. historical sketch. Also Wallach, Annalen, Bd. 227, p.

(*b.*) The inversion of pinene into dipentene by means of sulph acid was studied by Armstrong and Tilden; Berichte, Bd. 12, p. 1 Wallach, Annalen, Bd. 227, p. 283.

[3] Compare Terpinhydrate.

[42] [1] Comp. Wallach: "Pomeranzenschalenöl, Fichtennadelöl, Anna Bd. 227, p. 277.

[2] Comp. historical shetch, also Dissertation, p. 38.

[3] Comp. Disertation p. 46[9]. Hydrochloric acid acts like nitric a Annalen, Bd. 230, p. 266, Dissertation p. 45.

[43] Annalen, Bd 239, p. 14.

[45] Annalen, Bd. 239, p. 4.

[46] Annalen, Bd. 245, p. 196.

[47] Annalen, Bd. 230, p. 247 et. seq.

Ad. Monhydrochlorides.

[1] Journ. de Pharm., T. 26, p. 1.

[2] Ann. Chim. Phys., [3] T. 37.

[3] Compt. rend. T. 45, p. 904.

[4] Ibidem, T. 79, pp. 223 and 315. (J. C. S. Vol. 32, p. 1162.)

[5] Ibidem, T. 80, p. 1146. (J. C. S. Vol. 33, p. 1259.)

[6] Gazetta Chimica, T. 13, p. 99. (Berichte, Bd. 16, p. 1241.

[7] Compare e. g.:

Himly (1835) Annalen, Bd. 29, p. 40.

Schweizer, (1840) J. pr. Chem., Bd. 24, p. 257.

[8] Annalen, Bd. 239, p. 10.

[9] Ibidem, Bd. 241, p. 321.

Ibidem, Bd. 245, pp. 241 et. seq. (p. 248, also pp. 258–260.)

[10] Dissertation, p. 55.
[11] Ibidem, p. 40.
[12] Annalen, Bd. 245, p. 249.
[13] Ibidem, Bd. 245, p. 259.
[14] Ibidem, p. 260; Dissertation p. 46.
[15] Ibidem, p. —; ibidem p. 49.
[16] Dissertation, p. 45.
[17] Annalen, Bd. 230, p. 265.
[18] Ibidem Bd. 245, p. 259; Dissertation, p. 41.

It is of interest to note that the addition of one molecule of hydrogen chloride renders limonene more apt to polymerize. Disregarding the crystalline camphene (no doubt also fenchene) the terpenes with one double bond apparently polymerize more readily than those with two.

[19] Dissertation, p. 43.
[20] Ibidem, p. 39.
[21] Annalen, Bd. 245, p. 250.
[22] Dissertation, p. 51, etc.

ad Dihydrohalogen addition products.

[1] Ann. Chim. Phys., T. 13, p. 259.
[2] Ibidem, T. 52.
[3] Dumas proposes the ending ène for the hydrocarbons from volatile oils to avoid confusion with the alkaloids.
[4] Annalen, Bd. 6, p. 259.
[5] Ibidem, Bd. 27, p. 40.
[6] Ann. Chim. Phys. T. 66, p. 196.
[7] Comp. Monohydrochlorides — note [4].
[8] J. de Pharm. T. 26, p. 1.
[9] J. pr. Chem., Bd. 24, p. 257.
[10] Annalen, Bd. 67, p. 362.
[11] Ann. Chim. Phys. [3] T. 37.
[12] Ibidem [3] T. 61, p. 463.
[13] According to the nomenclature proposed by Berthelot in his "Chimie organique fondée sur la synthese" T. *II*, p. 735.
[14] Annalen, Bd. 129, p. 149.
[15] J. C. S., vol. 47, p. 787.
[16] Berichte, Bd. 17, p. 1975.
[17] Annalen, Bd. 227, p. 301, and Ibidem, Bd., 239, pp. 12 and 13.
[18] Compt. rend., T. 102, p. 433.
[19] The original names of these derivatives already indicate this fact. To the pinene monhydrochloride alone the term artificial camphor

("camphre artificiel") could be applied on account of its camphor like odor. The dipentene dihydrochloride, which has not the least resemblance with natural camphor could be called "camphre artificiel de citron" only because it was prepared from a similar natural product and in an analogous manner. The "camphre artificiel" proper was thereafter also termed "camphre artificiel de térébenthine."

[20] Memoirs de la Société D'Arcueil, T. 2, p. 23.

[21] Annalen, Bd. 27, p. 40.

[22] Ann. Chim. Phys. [3], T. 27, p. 80.

[24] J. C. S., vol. 17, p. 1.

[25] Table of melting points in chronological order:

1833. Blanchet & Sell, 43°.
1840. Soubeiran & Capitain, 50°.
1840. Schweizer, 50°.
1862. Oppenheim, 48°.
1884. Hell & Ritter 50-51°.
1885. Yoshida 58-59°.
1887. Weber 50° (Amalen, Bd. 238, p. 102).
1887. Wallach 50° (Ibidem, Bd. 239, p. 12).

[26] Can therefore be precipitated from its solution in glacial acetic acid with the aid of water.

[27] Tilden: Berichte, Bd. 12, p. 1131.
Wallach: Annalen, Bd. 239, p. 5.

[28] Wallach Ibidem, Bd. 230, p. 260.

[29] Wallach Ibidem, Bd. 239, p. 12. (Comp. B. & S. [4]).

[30] Comp. Dipentene: Regeneration.

[31] Annalen, Bd. 246, p. 267.

[32] First observed by Riban: Compt. rend. T. 79, pp. 223 & 314.
Confirmed by Wallach: Annalen, Bd. 245, p. 247.

[33] Comp. historical sketch.

[34] Hell & Ritter (1884): Berichte, Bd. 17, p. 1975.
Wallach & Brass (1884): Annalen, Bd. 225, p. 298.

[35] First observed by List[10] (1848) verified by Deville (1849); Ann. Chim. Phys. [3], T. 27, p. 80, and others, Wallach: Annalen, Bd. 230, p. 248 and ibidem, Bd. 239, p. 18.

[36] Oppenheim[14] (1862).

[37] Wallach: Annalen, Bd. 230, p. 265.
Comp. also Flawitzky; (1879) Berichte, Bd. 12, p. 2354 and (1887) ibidem, Bd. 20, p. 1956.
Bouchardat & Lafont (1886), Compt. rend., T. 102, p. 433.

[38] Berthelot[11] (1852).

[39]&[40] Annalen, Bd. 239, p. 44.

[41] Ibidem, Bd. 245, p. 267.

[42] Ann. Chim. Phys. [3], T. 61, p. 463.

[43] Annalen, Bd. 239, p. 13.
[44] Ibibem, p. 24.
[45] Ibidem, p. 3.
[46] Ibidem, Bd. 57, p. 247.
[47] Ibidem, Bd. 225, p. 302.
[48] Ibidem, Bd. 230, p. 249.
[49] Ibidem, p. 265.
[50] Ibidem, Bd. 239, p. 14 and Bd. 252, p. 128.
[51] Ibidem, Bd. 230, p. 249.

ad Terpinhydrate.

[1] According to Gmelin "Hand-book of Chemistry" 1860, vol. 14, p. 258.
[2] Repert. **9**, 276, and **22**, 419.
[3] N. Journ. d. Ph., Bd. 15, St. 2, p. 46.
[4] Jahresbericht **27**, p. 440.
[5] Annalen, Bd. 67, p. 362. List distinguishes between "Krystallisirtes Terpin $C^{20}\ \dot{H}^{17}\ 0 + 3\ H + 2$ aq.," and "Terpin ohne Krystallwasser, $C^{20}\ \dot{H}^{17}\ 0 + 3\ H$," p. 375.
[6] Annalen, Bd. 6, p. 267.
[7] Ibidem, Bd. 7, p. 167.
[8] Ididem, Bd. 33, p. 358.
[9] Ibidem, Bd. 52, p. 390.
List[5] rejects this term because according to his views the elements of water in the terpin are not present as "Hydratwasser." He also rejects the term "Terpentin campher" as inappropriate. He accepts the nomenclature of Bezilius[4-5]:
[10] Ann. Chim. Phys. [3] T. 27, p. 80. (Annalen, Bd. 71, p. 348.)
[11] Annalen, Bd. 230, p. 247.
[12] Ann. Chim. Phys., T. 57, p. 334 (1835). (Annalen, Bd. 14, p. 75.
The analyses of Dumas and Peligot pertain to crystals found in turpentine oil (*a*), in basilicum oil (Acimum basilicum, L) (*b*) and in cardamom oil (cardamomum minus) (*c*). They assign to these substances the formula $C_{40}\ H_{32} + H_{12}\ O_6$ and believe them to be *identical.* No doubt these crystals were terpin hydrate as also those obtained by Rammelsberg (Annalen, Bd. 52, p. 391.) from a mixture of turpentine oil, hydrochloric acid, "Spiritus cochleariae" and "Spiritus Serpylli."
[13] Blanchet and Sell mention Buchner,[2] Boisonot, Persot, Cluzel and Geiger (Mag. Pharm. **16**, 64), as chemists who have investigated "Terpenthin campher." B. & S. had not prepared the substance themselves but had recived it from Prof. Geiger who *probably* obtained it by heating moist turpentine oil for some time at a temperature of 50°. Based upon their analysis of the ("nicht vollkommen von anhangendem Oele

befreiten,") substance they assign to it the formula $C^{10} H^{16} + H^2 O^2 = C^{10} H^{20} O^2$, consisting therefore "aus einem Atom Terpenthinöl und einem Atom Wasser."

Blanchet (Annalen, Bd. 7, p. 167) obtained "Terpenthinhydrat" "durch vermischen des Oels (Wacholderbeerenoel) mit Wasser und hinstellen desselben in gewöhnlicher Temperatur, wo denn nach einigen Wochen das Hydrat *an den oberen Wänden des Gefässes krystallisirt.*" According to such a method pinol hydrate is obtained, not terpin hydrate.

[14] That Stenhouse, according to Wiggers' method, should not have obtained terpin hydrate, but a substance "$C_5 H_4 + HO$" (i. e. $C_{10} H_{20} O_2$) seems strange indeed. Analyses, physical properties and the odor of the dehydration product do not harmonize with those of terpin-hydrate, but with those of pinol-hydrate.

[15] Attempting to prepare terpin hydrate in one experiment (Annalen, Bd. 57, p. 247) Wiggers obtained according to his well known method "campher" within half an hour, which, however, disappeared after several hours. After that no further crystals would result. It would appear from the text that Wiggers had shaken the bottle whereupon the crystals dissolved. Under these conditions pinol hydrate might form in so short a time, but not terpin-hydrate.

List (Annalen, Bd. 67, p. 362) essentially verifies Wiggers' statements, and calls special attention to the fact that one molecule of water in terpin hydrate is present as water of crystallization.

Deville (Annalen, Bd. 71, p. 346) adds very little new. It is of interest, however, to note that he recognized the *identity* of the dipentene dihydrochloride obtained from terpin hydrate with that obt. from lemon oil.

[16] Sobrero first recognized the fact that by the action of oxygen in the presence of sunlight a hydrate is formed which differs from the "Terpentinölhydrat" of Wiggers. He assigns to it the formula "$C_{20} H_{16} O_2 + 2 H O$" [i. e., $C_{10} H_{18} O_2 = C_{10} H_{16} O + H_2 O$]. This substance recently designated as "soberol" by Armstrong (J. C. S., vol. 49, p. 315), is nothing more or less than Wallach's pinol hydrate (Annalen, Bd., 259, p. 313.)

[17] A compilation of the various crystallagraphic measurements can be found in Rammelsberg "Handbuch d. kryst. phys. Chemie." (1882) p. 449.

[18] According to Vulpius, J. C. S., 56, 1202 (from Chem. Centr., 1889, p. 789, from Pharm. Centralhalle, 30, 289.) The statement that terpinhydrate is soluble in 200 p. of cold and 22 p. of boiling water (Realencyclopædie der gesammten Pharmacie IX, p. 645) can be traced back to Blanchet and Sell (Annalen, Bd. 6, p. 266). It has been indicated that these chemists very likely had no terpin hydrate in hand but pinol hydrate.

[19] An alcoholic solution does *not* decolorize bromine; Wallach: (Annalen, Bd. 230, p. 248.)

[20] Ibidem.

[21] Ibidem, p. 271. The details of the dehydration experiments, p. 253.

[22] Ibidem, Bd. 239, pp. 18, 20, 23.

[23] Comp. Dipentene dihydrochloride: Historical notes.

[24] Observed first by Berthelot (Ann. Chim. Phys. [3] T 61, p. 463.)

[25] Comp. Dipentene dihydriodide: Historical notes.

[26] Oppenheim (1862). Annalen, Bd. 129, p. 149.

[27] Wallach, Ibidem, Bd. 239, p. 19.

[28] Ibidem.

[29] Ibidem, p. 20.

Oxidizing terpin with nitric acid Hempel (Annalen, Bd. 180, p. 71) obtained besides carbonic and oxalic acids chiefly toluic acid, $C^8 H^8 O_2$, terephthalic acid and terebinic acid $C^7 H^{10} O_4$. Oxidizing terpin with chromic acid he obtained terpenylic acid $C^8 H^{12} O^4 + H^2 O$. Already in 1856 Personne (Annalen, Bd. 100, p. 253) had obtained "Terebentilsäure $C_{16} H_{10} O_4$" by passing the vapor of terpin over hot soda-lime.

[30] Ibidem, Bd. 246, p. 267.

[31] Ibidem, Bd. 230, p. 249.

[32] Dissertation, p. 49.

[33] The first reliable method is that of Wiggers. Tilden obtained the same product from American and French oil of turpentine. The hydration takes place in the presence of acids:

1. Of nitric acid — Wiggers, Mansfield.
2. Of muriatic acid — Rammelsberg (Annalen, Bd. 52, p. 390.)

[3. Of sulphuric acid — Tilden, Wallach.]

[34] That the regeneration of terpin hydrate from terpineol takes place within a few days in the presence of dilute acids was observed by Tilden and confirmed by Wallach (Annalen, Bd. 230, p. 266).

[35] Dissertation, p. 45.

[36]	Oil.	Nitric Acid.	Alcohol.		
Wiggers.	8	2 (Sp. grav. 1.25—1.3) ..	1 (80 p. c.)..	Temp. 20-25°. Largest yield after 2 yrs. 1 oz. from 1 lb. oil.....	Annalen 57, 247.
Deville...	4 8	1 (Commercial). 2 (Commercial).	3 (85 p. c.) 6 (85 p. c.)	From 4 l. after 6 weeks 250 g: abt. 7.2 p. c....	Ibidem, 71, 348. (Ann. Chim. Phy. [3] 25, 80.)
Hempel..	8	2 (Sp. grav. 1.25—1.3) ..	2	.....	Annalen 180, 73.
Tilden....	2½ 8	1 (Sp. gr. 1.4)... 3.5	1 3.5	Tilden claims to have obtained a yield of abt. 33 p. c.....	J. C. S. 33, 248.
Schmidt..	8	2 (Sp. grav. 1.18) ..	2	.....	Pharm. Chem. II., 818.

ad Terpineol.

[1] Although much has been written about "Wiggers' terpinol" this term did not originate with Wiggers, but with List. List's terpinol is not identical with Wallach's terpineol but a mixture of the latter substance with hydrocarbons $C^{10}H^{16}$ (probably dipentene and terpinene). However, Berthelot[3] already employed the term terpinol for a substance $C^{10}H^{18}O$, whereas Oppenheim[4]. falls back upon List's formula $C^{20}H^{34}O$, although he acknowledges that the substance under consideration is most likely no chemical unit and even quotes Gerhardt[4], who does not believe in the existence of such a body. Tilden[5]. again declares List's terpinol to be a mixture, nevertheless he retains the term for his monatomic alcohol $C^{10}H^{18}O$. The same must be said of Tanret[6].

[2] Annalen, Bd. 67, p. 362.

[3] Ibidem, Bd. 83, p. 106. (Compt. rend., T. 34, p. 799.)

[4] Ibidem, Bd. 129, p. 149.

[5] J. C. S., Vol. 33, p. 247, and
Ibidem, Vol. 35, p. 286.

[6] Ibidem, Vol. 48, p. 990. (J. de Pharm. [5] T., 11, p. 506.

[7] Berichte, Bd. 12, p. 2354, and
Ibidem. Bd. 20, p. 1956.

[8] Annalen, Bd. 230, p. 254.*

[9] Compt. rend. T. 104, p. 996.

[10] Annalen, Bd. 57, p. 252.

[11] Compt. rend., T. 102, pp. 50, 318, 433 and 1155.

[12] Ibidem, T. 54 ?, p. 845.

[13] Bouchardat and Voiry[9] claim to have obtained crystals of "tepilenol" prepared from terpin, that melted at 30-32°.

[14] Annalen, Bd. 230, p. 265.

[15] Terpineol from its acetate (from pinene) 218-223° B. & L.[11]
Terpineol from terpinhydrate 218° B & V.[9]
"R-Terpenhydrat" of Flawitzky[7] 213.7-217.7°.
"L-Terpenhydrat" of Flawitzky[7] 217.7-220.7°.

[16] Comp. "Cautschene Monochlorhydrate" B. & L.[11]
Comp. Terpineol, Wallach, Annalen, Bd. 239, p. 21.

[17] From acetate prep. from —pinene $[\alpha]_D = -64.3°$ B. & L.[11]

"L-Terpenhydrat of Flawitzky"[7] $[\alpha]_D = -56.2°$.

"R-Terpenhydrat of Flawitzky"[7] $[\alpha]_D = +48.4°$.

"Terpilenol" from citrene through the acetate $[\alpha]_D = +67° 31'$ Lafont.[12]

[18] Spec. Gravity = 0.961 at 0°, Bouchardat & Lafont.[11]
0.952 Bouchardat & Voiry.[9]

0.9339 at 0°
0.9340 at 0° } Flawitzky.[7]

0.940 at 15°
0.935 at 20° } Schimmel & Co., Bericht, Oct '90, p. 52.

[19] It readily absorbs bromine. The bromide, however, is solid at very low temperatures only. Allowed to stand with an excess of bromine dipentene tetrabromide is formed. Wallach, Annalen, Bd. 230, p. 266.

[20] Tilden already observed that in alcoholic solution of "terpinol" acidulated with nitric acid crytals of terpinhydrate are generated J. C. S. vol. 33, p. 250. Wallach observed that very dilute hydrochloric or sulphuric acids at *ordinary temperatures* favor the addition of water.

[21] Since terpinene and terpinolene are products of inversion of limonene and dipentene the terpineols and terpin must be regarded as derivatives of the hydrocarbons of the limonene group, but not of the pinene group. This view is supported by the conversion of the terpineols into dipentene tetrabromide[19] and into the dihydrohalogen derivatives of dipentene.

[22] Comp. historical notes: Wallach (1885).

[23] List, Annalen, Bd. 67, p. 370.
Tilden, J. C. S., vol. 33, p. 249.

[24] Wallach, Annalen, Bd. 230, p. 267.
Flawitzky, Berichte, Bd. 20, p. 1960.

[25] From the method of formation of the monochlorhydrates of the limonenes we know that by the action of hydrogen chloride upon terpineol the monochorine ester (if this is identical with limonene monohydrochloride) could not be found. In this reaction water would be generated and thus the conditions favorable to the formation of the monochloride would be destroyed. For the formation of terpin-hydrate from the monochloride comp. Dissertation p. 45.

[26] Oppenheim, Annalen, Bd. 129, p. 157. This substance also appears to result from the action of acetic acid on pinene (B. and L.[11]), upon limonene (L[12]) and upon dipentene (B. and L.[11])

[27] Comp. methods of formation of terpin hydrate, also Wallach, Annalen, Bd. 239, p. 19.

[28] Wallach, ibidem, p. 21.

[29] Wallach, ibidem, Bd. 230, p. 267.

[30] Wallach, ididem, Tilden, J. C. S., vol. 35, p. 288.

[31] Annalen, Bd. 246, p. 267.

[32] ad I. Terpene hydrates of Flawitzky[7].

ad II. List[3]: by means of very dilute sulphuric acid (p. 367.)
Berthelot[3]: action of heat alone, chlorides of zinc, calcium strontium and ammonium, fluoride of calcium.
Tilden[5]: by means of dilute hydrochloric acid, (p. 248.
Wallach[8]: by means of dilute sulphuric acid, phosphoric acid, glacial acetic acid and potassium disulphate.

ad III. [1] Bouchardat and Lafont[11]: Acetates from pinene and dipentene.
Lafont[12]: Acetate from + limonene.
[2] Oppenheim[4]: Dipetene 2 H Br. with silver acetate (p. 154.)
Oppenheim[4]: Dipentene 2 H I with ammonia (p. 156.)
List[2] (p. 373.)
Berthelot[3] (according to Oppenheim.)
Tilden[5] (p. 249.)
} By boiling the dihydrochloride with water.

Many of these references must be taben with considerable reserve. In most cases no pure terpineol was obtained. However, it is to be assumed that in all cases more or less of it was formed.

[25] According to Tilden[5] (p. 289) lemon oil contains 10-15 p. c. of a substance which has the same boiling point with terpineol and yields a dichloride melting at 48°. This "natural terpinol" is stated to be dextrogyrate. So called "Cajeputol" is stated to contain a fraction which boils above 200°, which is capable of yielding a dichloride melting at 48°.

Weber (Annalen, Bd. 238, p. 101) separated from cardamom oil a fraction 205-220°, which yielded dipentene dihydrochloride, melting at 52°. He did not succeed in making the carbanil reaction.

Watts (J. C. S. vol. 49, p. 316) has sufficient faith in an insignificant color reaction to conclude from it the presence of terpineol in the oil from the leaves of Citrus Limetta.

Bertram and Gildemeister (Archiv d. Pharm. Bd. 228, 485), assume the presence of terpineol beside borneol in the fraction 200-220° of kesso-oil (valeriana officinalis, var. angustifolia.) They obtained from this fraction dipentene dihydriodide melting at 76°. The oil also contains dipentene.

Kwasnick (Berichte, Bd. 24, p. 81) reports as follows of a fraction from Kuro-moji-oil (Lindera fericia, Bl.): "Eine angenehm nach Fliederbluehten riechende Fluessigkeit C_{10} H_{18} O, siedet bei 218° und wurde durch sein Verhalten gegen Chlorwassertoff und gegen Brom, sowie durch sein schoen hrystallisirendes Jodid, welches bei 75-76° schmilzt, identificirt." This oil also contains + limonene, dipentene and — carvol.

ad Nitrosochlorides, etc.

[1] J. C. S. (1877), Vol. 31, p. 558.
[2] Annalen, Bd. 245, p. 245.
[3] J. C. S. (1875) p. 514 and ibidem (1877), p. 554.
[4] J. C. S. 1864.
[5] Berichte, Bd. 18, pp. 1729 and 2220.
[6] Annalen, Bd. 245, p. 241.
[7] Ibidem, Bd. 252, p. 108.
[8] Ibidem, p. 109; Comp. also ibidem, Bd. 245, p. 255, and Dissertation, p. 18.
[9] Ibidem, Bd. 252, p. 111; also "Wissenschaftliche Beilage zum Jahresbericht des Elizabeth Gymnasiums, Breslau, Ostern '90.
[10] Ibidem ,p. 124.
[11] Dissertation, p. 22.
[12] Annalen, Bd. 252, p. 125.
[13] Annalen, Bd. 252, p. 145.
[14] Ibidem, p.112.
[15] Dissertation, p. 23.
[16] Annalen, Bd. 252, p. 146.
[17] Dissertation, p. 24.
[18] Annalen, Bd. 245. p 256.
[19] Ibidem, Bd. 245, p. 257, and
Ibidem, Bd. 246, p. 224.
[20] Ibidem, Bd. 245, p. 268, and
Ibidem, Bd. 246, p. 227.
[21] Ibidem, Bd. 245, p. 257.
[22] Ibidem, Bd. 252, pp. 111 and 125, also
Dissertation, p. 24, et. seq.
[23] Annalen, Bd. 245, p. 258.
[24] Ibidem, p. 270.
[25] Wallach, "Nitrosate and Nitrosite" etc., Annalen, Bd. 241, p. 288.
Wallach, Sechste Abhandlung Ibidem, p. 315.
Wallach, Siebente Abhandlung Ibidem, Bd. 245, p. 241.
Wallach, Elfte Abhandlung Ibidem, Bd. 252, p. 106.
Kremers, Dissertation.
[26] Annalen, Bd. 245, p. 271.
Ibidem, Bd. 252, pp. 113, 125 and 146.
[27] Ibidem, pp. 121, 126 and 147.
[28] Ibidem, pp. 118 and 126, also.
Dissertation, pp. 24 and 60.
[29] Dissertation, p. 29.
[30] Dissertation, p. 34.

[31] Annalen, Bd. 245, p. 260.
Dissertation, p. 46.
[32] Annalen, Bd. 245, p. 260.
Dissertation, p. 49.
[33] Annalen, Bd. 245, p. 265.
[34] Dissertation, p. 51.
[35] Annalen, Bd. 245, p. 262.
Dissertation, pp. 55 and 34.
[36] Ibidem, p. 60.

THE PSEUDO-GREGORIAN DRAMA Χρίστος Πάσχων IN ITS RELATION TO THE TEXT OF EURIPIDES.

By F. L. VAN CLEEF, Ph. D.

PART I.—THE BACCHAE.

The Christian Drama Χρίστος Πάσχων, which by its superscription is ascribed to Gregorius Nazianzenus, has been clearly shown by Dœring and Brambs not to be in accord with the other writings of Gregorius and assignable not to him but to a much later writer. Dœring[1] attributed it to Tzetzes but Brambs,[2] who has most recently and most thoroughly studied the problem, assigns it with seemingly greater right to Theodorus Prodromus or an author of that period, i. e. of the 11th or 12th century.

The drama is a cento constructed of lines taken from the Prometheus and Agamemnon of Aeschylus, the Cassandra of Lycophron, the Holy Scriptures including Genesis, Exodus, the Psalms, the four Gospels, the letters of Paul and even the Apocryphal books; but mainly, as the writer acknowledges in his introduction (v. 3 sq.), from Euripides, of whom he has used seven plays known to us, Hecuba, Orestes, Medea, Hippolytus, Troades, Rhesus and Bacchae. From these plays it is evident that the MS. of Euripides, that the writer had in his possession, must have been the second of the two classes, into which Kirchhoff has divided our existing MSS. of Euripides, and that no more plays were used may be accounted for on the supposition that the MS. used by the writer contained only the seven above-mentioned plays, with which were perhaps bound the two mentioned plays of Aeschylus and the Cassandra of Lycophron. That the writer had no other plays of Euripides before him seems certain from the fact that he has plundered these in a most thorough manner, not con-

[1] De tragoedia Christiana quae inscribitur Χρίστος Πάσχων, Realschulprog. Barmen, 1864, p. 8.

[2] De auctoritate tragoediae Christianae quae inscribi solet Χρίστος Πάσχων Gregorio Nazianzeno falso attributae. Diss. inaug. scripsit J. G. Brambs, Eichstadii, 1883, p. 64. Cf. also the Praefatio of Brambs' edition of the Christus Patiens, Teubner, 1885, p. 17 sqq.

tent to take here and there a line. Everything that could be of s
has been utilized and the remarkable thing is that he was not temp
use the same line twice. Indeed he seems to have checked off eac
as fast as used and never to have repeated it without considerable
tion. Nor has he taken the verses in their original order but w
brought together in the same speech verses not only of different spe
but taken from very different portions of the same play. Thus c
prologue of the Medea verses 20-39 (excepting only 23, 24
29) have been used by the writer of the *Χρίστος Πάσχων* as fo
V. 20 = 4 of the *Χρ. Π.*; 21 sq. = 51 sq.; 25 sq. = 46 sq.; 27 sq. = 97
30 = 974; 31 sq. = 945 sq.; 33 = 949; 34 — 36 = 53 — 55; 37 = 489; 38 =
39 = 491. From this it is plain that he was so thoroughly master of
sixteen verses that he has interspersed them in one thousand lines
drama.

Inasmuch as we have here excerpts from plays of Euripides
served in some cases in a single manuscript and in others in only t
would seem probable at first consideration that this cento would
great value in determining the text of Euripides. This question
early investigated, soon after the appearance of Kirchhoff's cr
edition of Euripides, by A. Dœring.[1] Kirchhoff had previously poi
out the fact that the MS. of Euripides used by the author of this
contained without doubt the portion of the Bacchæ after v. 1328, w
our present MS. lacks, and hence was derived from an archetype w
contained the whole of that play.[2] But Dœring, after citing all t
passages in which the *Χρ. Π.* had preserved, as he judged, the real
ing of Euripides, reached the conclusion that the MS. used by
author of the *Χρ. Π.* was inferior to the MSS. of Class I but superi
those of Class II of the Euripidean MSS. It is my intention in this
per to investigate the problem more thoroughly and to set forth cle
both sides of the shield, inasmuch as there was a feeling that but
side had been clearly shown in the articles of Dœring in Philolo
And that the paper may not be too colossal in its magnitude, it has
decided to limit the present investigation to one play of Euripides,
Bacchæ, preserved in only two MSS., a Palatinus 287 of the 14th cent
(designated by the letter P.) and a Florentinus XXXII (known by
designation C.) also of the 14th century which, however, contains but
first half of the play, lacking all from verse 756 on to the end (1392).
the writer of the *Χρ. Π.* has taken from the 1392 lines of the Bacchæ
extracts from those portions now lost in our MSS. do not come here
consideration) over 250 lines for his cento, over half of which are f

[1] Die Bedeutung des Tragœdie *Χρ. Π.* für die Textkritik des Rhe
Philologus 23 (1866), pp. 577-591, and Die Bedeutung der Tragœdie *Χρ.*
für die Euripidestextkritik, Philologus 25 (1868), pp. 221-258.

[2] Ein Supplement zu Euripides' Bakchen, Philologus 8 (1853), pp. 78

the latter half of the play, preserved in a single MS. of the 14th century, there would seem to be good opportunity in this play for determining the value of the citations as found in the *Χρ. Π.* for the text of the Bacchæ.

It must first be remarked that, as the subject of the cento did not often allow its author to quote directly without change from his chosen model, we expect to find many variations from Euripides occasioned by this fact, and do not expect to find many lines to be taken *verbatim* Bearing this in mind three classes of citations as made by the author of the *Χρ. Π.* may be distinguished.

I. Those verses in which one or more words have been necessarily changed to bring into harmony with the theme the heathen conceptions of Euripides. This class also includes all those verses in which by reason of the context some change has been made. The verses in this class must necessarily constitute the great majority of all the verses quoted and we add here the list that it may be of service to any who may desire to investigate the question further.[1]

1 = *Χρ. Π.* 1573 (?)	29 = 1553	60 = 2519
2 = 1545 (?)	30 = 1555	61 = 2520
4 = 1546, 1533, 1535 sq.,	31 = 1552 (?)	69 = 1608
1543, 1758 sq.,	40 = 1568	71 = 1607
2395, 2405, 2574[2]	47 = 1574, 1564	72 sq. = 1139
7 = 1582	48 = 1565	73 sq. = 1140
10 = 1585	50 = 1575	75 sqq. = 1141
11 = 1586	51 = 1576	80 sqq. = 1142, 1144
21 = 1563[3]	52 = 1577, 1536, 1543	120 = 1599
26 = 1547	53 = 1512, 2374	179 = 1149
27 = 1550	54 = 1536, 1543	180 = 1150
28 = 1551	58 = 1606, 1124	181 = 1152

[1] The first and only complete list of quoted verses that exists is to be found in the preface of Brambs' edition in the Teubner series, p. 8 sqq. The list of verses quoted from the Bacchæ (p. 15 sqq.) is almost complete. I have added but two further citations. In a considerable number of instances the parallelism as there referred to is so very remote as to be of no value for our investigation, and to leave great doubt in the mind if the verse is really modeled after that of Euripides.

[2] When more than one verse of the *Χρ. Π.* is cited as a parallel of a verse from the Bacchae, the one that stands first is the real corresponding verse, the others may be neglected, as corresponding only vaguely with the given line.

[3] The proposal to read here the future participles *χορεύσων καὶ καταστήσων* from the evidence of the *Χρ. Π.* is neither consonant with the context, nor demanded by the *Χρ. Π.* For it is not true that the tense has never been changed in the *Χρ. Π.* Such a change occurs in 280 = 571; 1120 = 2564; 1128 = 1162; 1237 = 163; 713 = 2218; 213 = 1561; 777 = 2245; 955 = 1506; 1077 = 2254; 1223 = 2202.

183 = 1153	447 = 2075	973 = 1306, 1295
186 = 1156	450 = 1655	995 (= 1015) = 1437
187 = 1157	489 = 1556	1025 = 1648
213 = 1561	492 = 1668	1026 = 1649 sq. [4]
231 = 1558	666 = 2212	1027 = 647, 1601
232 = 1559, 1557 [1]	670 = 2222	1030 = 438, 654
240 = 1557 [2]	678 = 1845	1031 = 1535, 2100, 2542
248 = 1136	683 = 1833	1032 = 652, 2192
264 = 193	684 = 1835	1043 = 657
265 = 194 sq.	685 sq. = 1836	1044 = 658
280 = 571	693 = 2018	1046 = 675
283 = 570	712 = 2216	1050 = 678
287 = 572	732 = 1812, 1810	1064 = 660
288 = 575	733 = 1811, 2039	1065 = 661
289 = 577, 585	760 = 1101 (?)	1068 = 663
290 = 579	761 = 1102 (?)	1069 = 566
291 = 580	769 = 2262	1073 = 662
306 = 587	770 = 2263	1077 = 2254
307 = 588	772 = 2265	1079 = 2257
309 = 584	774 = 2266	1082 = 2258
313 = 586	775 = 2221	1085 = 2261
315 = 263 [3]	777 = 2245	1086 = 671, 2013
333 = 599, 565	779 = 2228	1088 = 170, 2016
335 = 1032, 565, 599	780 = 2229	1089 = 2017, 171
360 = 1788	788 = 2278	1095 = 666
361 = 1789	789 = 2279	1097 = 668
362 = 1790	790 = 2280	1113 = 1432
363 = 1791	846 = 2287	1118 = 2566
389 sq. = 1801	854 = 2311	1128 = 1162
390 = 1803	960 = 1522	1135 = 1473
391 = 1804	962 = 1524	1143 = 1167
442 = 1384 (?)	963 = 1525	1144 = 1062
443 = 1385, 1928	964 = 1526	1202 = 1598
445 = 2070, 2073	967 = 1521	1214 = 1264
446 = 2074	972 = 1531	1215 = 1265

[1] The change of *παύσω* to *στήσεις* is doubtless due to the fact that the author of the *Χρ. Π.* had already used *παύσεις* in 1557. After substituting *κακουργίας* for *τῆσδε βακχείας* he could scarcely retain *κακούργου* and hence changed it to *κακοῦργον*.

[2] This similarity has been overlooked by Brambs.

[3] The dative of the *Χρ. Π.* is partial testimony to the dative of C., P., and Stob. 5, 15. Stobaeus 74, 8 reads *εἰς τὴν φύσιν*.

[4] *ἐν γῇ* of the *Χρ. Π.* testifies somewhat to *ἐν γαίᾳ* of P. and against Wecklein's emendation, *ἐν γυίαις*.

1217 = 1486	1280 = 1310, 444, 853	1339 = 2573
1219 = 1487	1281 = 854	1340 = 1685
1221 = 1488	1314 = 1342	1346 = 2562
1226 = 1455	1315 = 1343	1352 = 1700
1233 = 161	1327 = 1712 sq.	1353 = 1701
1239 = 165	1328 = 1714	1356 = 1671, 1758
1240 = 166	1332 = 1760	1360 = 1684, 1695
1243 = 169	1333 = 1680	1362 = 1697
1259 = 1053	1335 = 1683, 1678	1366 = 1703
1260 = 1890	1336 = 1678	1368 = 1706
1262 = 1056, 1892	1337 = 1681	1369 = 1706 sq., 1669, 1756.
1263 = 1058	1338 = 1752, 1682	

II. The second class of citations consists of those verses which are quoted exactly as we have them in our existing Euripidean MSS. This list is even larger than we should have expected and embraces fifteen lines, the enumeration of which is here given:

	Bacchæ.	*Χρ. Π.*
Found in both P. & C.	39	= 1567
	178	= 1148
	316[1]	= 264
	668[2]	= 2219
	669[3]	= 2220
	679	= 1846

[1] This verse which stood clearly in the Eur. MS. of the author of the *Χρ. Π.* at this place, as in the two MSS. of the Bacchae, (for *Χρ. Π.* 314 — 316 = Bacch. 262 — 264) is rejected by Kirchhoff and Wecklein, (Cf. the latter's Curae Criticae, p. 18. Wecklein considers it a dittograph of Hipp. 79.) because it was lacking in Stobaeus 74.8, who quotes the whole passage. Nauck, on the other hand, following Dindorf, rejects Hipp. 79–80 as spurious, and retains our verse. If the verse is to be rejected, then the MS. used by the author of the *Χρ. Π.* is in no way superior to our Euripidean MSS. and the interpolation must have been made in the common archetype of our MSS. and that in the possession of the author of the *Χρ. Π.*

[2] MS. A. of the *Χρ. Π.* reads πότερ' ὡς, V. πῶτερον (omitting σοι). Caillau's Benedictine edition of 1840 (*Χρ. Π.* appended to the works of Gregorius Naz.) πρῶτον σοι. This variance we shall have occasion to mention later.

[3] Here the *Χρ. Π.* agrees with our Euripidean codices in reading τἀκεῖθεν, which Brunck, whom all subsequent editors have followed, changed to τὰ κεῖθεν.

Found in P. alone
- 771 = 2264
- 794[1] = 2268
- 795 = 2269
- 838 = 1930
- 1078 = 2256
- 1112 = 1431
- 1152[2] = 1147
- 1261[3] = 1055
- 1361 = 1696

III. So far we have made no distinction between the MS. of used by the author of the *Χρ. Π.* and the existing MSS. of the Ba It is in the third class of citations that we shall have occasion to s how much value the citations from Euripides found in the *Χρ. Π* This class includes all those verses in which no particular reason s to exist to justify a change, and yet, which show some variation fro MS. readings of the Bacchæ. Here three sub-divisions are to be di guished. A. those cases in which the *Χρ. Π.* presents a reading so pl superior to our MSS. reading that it has been adopted by Kirchhoff all who have followed him: B. those cases in which the *Χρ. Π.* off reading which has appeared to some of the editors of Euripides wo of adoption or in which the readings presented by the *Χρ. Π.* see least equally good with those of the MSS.: C. those cases in which *Χρ. Π.* presents a corrupt reading, although there is no apparent re to justify the corruption.

A. The verses in which the readings of the *Χρ. Π.* have been ado by all the editors of Euripides in preference to those of our Euripi MSS. are the following:

1. 55. C. & P. *λιποῦσα, λιποῦσαι* C[2] as also *Χρ. Π.* 1602, Et. M. 45 while Strabo, 469, testifies at least to the ending – [Here as in a number of other cases the testimony of *Χρ. Π.* is entirely ignored by Kirchhoff.]
2. 655. P. & C. read *σοφὸς σοφὸς εἶ.* But the *Χρ. Π.* 1529, *σοφὸς σ σύ.*
3. 694. P. & C. read *παρθένοι τε κἄζυγες.* The *Χρ. Π.* on the o hand has *παρθένοι τ' ἔτ' ἄζυγες* which all have adop Usener's conjecture, (Rh. Mus. XXIII. 160) *σύζυ*

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[1] MSS. V. and B. of the *Χρ. Π.* *αὐτὸν.*

[2] MS. P. and the *Χρ. Π.* read *χρῆμα.* Orion, Anth. 4, p. 55, reads *κτῆ* which all the editors have adopted. (Nauck adopts without any not the change!) Here again, if the MS. of Euripides is wrong, the *Χρ. Π* wrong with it, and the corruption is to be traced to the archetype o and the Euripidean MS. of the *Χρ. Π.*

[3] Bruhn proposes for *μένειτ' μενοῖτ'* against the combined testim of P. and the *Χρ. Π.*

κἄζυγες, seems extremely probable, in which case the Euripidean MSS. have preserved the reading better than the *Χρ. Π.*, although both have been corrupted by the incorporation of the gloss, παρθένοι, into the text.

The remainder of the cases are from the portion of the play preserved only in codex P.

4. 778. P. reads ἐφάπτεται. But the *Χρ. Π.* 2227 ὑφάπτεται. (But codex V. of the *Χρ. Π.* shows the same corruption ἐφάπτεται.)
5. 1031. σύ om. codex. But the *Χρ. Π.* 2100 and 2542 retains σύ, though the order of the words is changed. Kirchhoff is followed in the insertion of σύ by Nauck and Bruhn. Other editors have suggested other methods of restoring either the dochmiacs or a trimeter. At the best the reading of the *Χρ. Π.* cannot be regarded as very much superior to that of the Palatinus.
6. 1041. P. τίνει. But *Χρ. Π.* 653 τίνει.
7. 1049. P. ἐκποδῶν. *Χρ. Π.* 677 ἐκ ποδῶν.
8. 1096. P. κραταβόλους. *Χρ. Π.* 667 κραταιβόλους.
9. 1151. P. οἶμαι γ'. *Χρ. Π.* 1146 and Orion, Anth. 4, 55 οἶμαι δ'. [Here again K. ignores the additional testimony of the *Χρ. Π.*] Reiske changed to ταὐτό, which Paley follows.
10. 1161. P. ἐξεπράξατο. *Χρ. Π.* 1050 ἐξεπράξετε. Scaliger had suggested the change, to whom K. and W. ascribe the reading.
11. 1344. P. λισσόμεθα. Codex V. of *Χρ. Π.* 2557 λισσόμεσθα, the remaining codices agree with the Palatinus. Musurus changed to λισσόμεσθα, to whom the emendation is ascribed by K. and W. with no reference to the *Χρ. Π.*
12. 182. This verse seems rightly rejected here, as Dobree has done, not only because it is a paraphase of 860 but because the *Χρ. Π.*, which quotes the whole passage from 178 to 187 in verses 1148–1157, entirely ignores the existence of this verse. Evidently it was not to be found in his MS. of the Bacchae, else he had made use of it for his theme.
13. 1213. P. πλεκτῶν. *Χρ. Π.* 1263 πηκτάς, from which Barnes drew the emendation πηκτῶν. The passage will be treated again.
14. 1345. P. ἐμέθεθ' which Musurus corrected to ἐμάθεθ'. The mistake is not to be found in *Χρ. Π.* 2560, where the form given is ἐμάθομεν.

B. Verses in which the reading presented by the *Χρ. Π.* seems at least as good as that of our MSS. of the Bacchae.

1. 1048. P. πικρόν, which Musurus emended to ποιηρόν. The *Χρ. Π.* 676 reads χλοηρόν. The passage is ably treated by Doering (Phil. XXV. (1867)). ποιηρός is found twice in

classical Greek and both occurences are in the Cyclops of Euripides, 45 and 61. χλοηρεῖ is the form in P. at Bacch. 106, χλοηρεῖ with ου *suprascr.* in C. Cf. Wilamowitz, Anal. Eur. p. 47. Hermann on this passage, reasoning from the analogy of κισσήρης, decided that χλοήρει was to be read here. For our passage we must assume a co-ordinate form χλοηρός, although it does not occur elsewhere. It were possible to read in the *Χρ. Π.* χλοήρες or χλοηρές to bring it into harmony with Bacch. 106. There was no reason why the author of *Χρ. Π.* should have made a change and he doubtless found χλοηρόν in his MS. of Euripides.

2. 1084. P. εὔλειμος. But *Χρ. Π.* 2260 ὕλιμος. εὔλειμος is a ἅπαξ λεγόμενον. ὕλιμος is said to be found in frag. 395. 34. Cf. Wilamowitz on this line in Bruhn's edition of the Bacchae.[1] And Doering rightly notes (Phil. XXV. (1867)) that ὕλιμος agrees better with φύλλ' εἰχε of 1085 and strengthens the idea of σίγα, while εὔλειμος seems an unnecessary epithet of the νάπη. Εὔλειμος could easily have arisen from ὕλιμος by reason of the pronunciation. Inasmuch as ὕλιμος is rightly constructed (cf. χρήσιμος, δόκιμος, etc.), occurs elsewhere (?) and suits the context better, while εὔλειμος is as least somewhat suspicious in its formation. Bruhn inserts the former in the text, while Wecklein decides also in its favor.

3. 1353. The line in P. has only five feet. The probable completion of the line, πάντες, was suggested by Kirchhoff from *Χρ. Π.* 1701 πάντας. This emendation has been adopted by Schoene and Bruhn. Other editors have proposed other solutions of the difficulty, while Paley desired to reject the verse entirely. πάντες seems the simplest emendation and the only one that has the slightest authority.

4. 787. P. reads λόγων κλύων. But the *Χρ. Π.* 2277 κλύειν λόγων. Nauck preferred to change to κλύων λόγων. The use of the infinitive in the *Χρ. Π.* seems justified by the difference in meaning, as Doering (Phil. XXV.) has shown, but the transposition can be due only to one of two causes. 1. Because the author of the *Χρ. Π.* found the words in their transposed order in his MS. of Euripides; or 2. Because

[1] I have been unable to find the citation. On careful inspection of the references to the fragments of Euripides in Bruhn's edition of the Bacchae it is not at all evident what edition he made use of, as the numbers correspond in no instance with the editions within my reach, viz. the older collections of Matthiae and Dindorf and the editions of Wagner and Nauck.

he made an arbitrary change in the Euripidean text. The latter seems to be the reason in this case. As the next line in the *Χρ. Π.* ends with *κλύων*, its author apparently desired to avoid the simularity of endings and so changed the order of words in this line. There seems to be no reason for preferring with Nauck the reading *κλύων λόγων*.

5. 14. The line is lacking in C. P. and Strabo I. 27 and XV. 687 read *Περσῶν θ'*, which Elmsley wished to emend to *δ'* and Wecklein, who in 16 reads *ἐπῆλθον* for *ἐπελθών* from Strabo XV. 687 (although Str. I. 27 gives *ἐπελθών*), drops *θ'* altogether. Wecklein however says nothing of the testimony of the *Χρ. Π.* 1588, which also omits *θ'* but preserves the participle in verse 16, though changed to *παρελθών*.

6. 20. P. and C. *πόλιν*. But *Χρ. Π.* 1595 *χθόνα* which Schenkl and Wecklein have taken into text, who also place verse 20 after 22. In the order of lines preserved by our MSS. the similar endings of 19 & 20, *πόλεις* and *πόλιν*, seem objectionable. But if the order be changed that objection is removed.

We may also include under this head those cases in which the citations from the *Χρ. Π.* agree with one of the MSS. and not with the other. They are as follows:

1. 75. P. *θιασσεύεται*. But C. and the *Χρ. Π.* 1141 *θιασεύεται*. This statement rests upon Bruhn's Kritischer Apparat. Wilamowitz in his Analecta Euripidea does not note this variance of the MSS., so that it seems at least questionable.
2. 46. P. *οὐδαμοῦ* with which the *Χρ. Π.* 1571 agrees. C *οὐδαμῶς*.
3. 56. P. *ξυνεμπόρους*. C. and the *Χρ. Π.* 1603 *συνεμπίρους*. All editors follow MS. P.[1]
4. 314. P[2] with Stobaeus Flor. 5.15 and 74.8 read *μὴ σ' ωφρονεῖν*. P. C. and the *Χρ. Π.* 262 *σωφρονεῖν* without *μὴ*.

In the following passage the thought rather than the word of the *Χρ. Π.* has furnished Hartung (whom Schoene & Bruhn have followed) with a plausible correction of MS. P. 1090–1 *ἥσσονες* || * *ἔχουσαι* certainly cannot stand. Kirchhoff, following Heath, reads for *ἥσσονες ἥσσονα* and retains *ἔχουσαι*. Wecklein prefers to bracket 1091. The three

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[1] In 443 = *Χρ. Π.* 1385 and 1928 the MSS. of Euripides read *ἅς*, *συνήρπασας*: *Χρ. Π.* 1385 *οὕς συν-* but 1928 *οὕς ξυν-* Such a point is entirely beyond the evidence of late MSS., as seems also the case under consideration. It is only given to give the benefit of the doubt to the *Χρ. Π.* A similar question is that of *ἐς* and *εἰς*. Cf. 450 = *Χρ. Π.* 1655; 1073 = 662. Likewise *-η* or *-ει* in second person singular middle of the verb. Cf. 787 = 2277 and 2286; 960 = 1522. So also the *ι* subscriptum in the verb *σώζω*; cf. 1050 = 678: and the accent of *σίγα*; cf. 1084 = 2260.

above-mentioned editors draw from the signification of δράμωσι of the *Χρ. Π.* 2015 and the form of the reading of P. the emendation τρέχουσαι.

C. So far we have regarded the readings afforded us in any way by the *Χρ. Π.* as either superior or equal in value to those of our MSS. of the Bacchae. In Class C. will be collected all those passages in which the author of the *Χρ. Π.* has apparently with the utmost arbitrariness changed the Euripidean text or with a more charitable supposition found in his MS. a very corrupted form of the Euripidean text.

1. 8. *Χρ. Π.* 1583 has τεφρούμεν' for τυφόμενα and ἄσβεστον for ἔτι ζῶσαν. These changes were doubtless made to avoid the resolved feet. The Euripidean line is unmetrical and difficult. Barnes emended by dropping τε and he has been followed by all the editors but the line is not relieved of all its difficulties.
2. 9. *Χρ. Π.* 1584 πρὸς τήνδ' for εἰς ἐμήν. The same variation is found in
3. 312. *Χρ. Π.* 584 πρὸς γῆν for εἰς γῆν and
4. 776. *Χρ. Π.* twice (2244 and 2222) πρὸς τὸν τύραννον for εἰς τὸν τύραννον. Of these three cases the first may have been due to the context. To obtain a final long syllable in πόλιν, πρὸς may have been written after it instead of εἰς. But this explanation will not hold for the other two instances and the author of the *Χρ. Π.* does not elsewhere show such attention to the laws of quantity. A short ι lengthened under the influence of the accent is not a rare phenomenon in the *Χρ. Π.*
5. 13. *Χρ. Π.* 1587 πανευκλεεῖς πόλεις for πολυχρύσους γύας. The reading of the *Χρ. Π.* is testimony to the accusative. Elmsley, followed by Wecklein, reads πολυχρύσων.
6. 16. *Χρ. Π.* 1590 παρελθὼν for ἐπελθὼν. Here also Ἀρράβων for Ἀραβίαν to avoid the resolved foot. ἐπελθὼν is the reading of Str. I. 27, but Str. XV. 687 gives ἐπῆλθον, which Wecklein has adopted.
7. 22. *Χρ. Π.* 1564 ἐμφανῶς for ἐμφανὴς. Similar is
8. 993 = 1013. *Χρ. Π.* 1099 φανερῶς for φανερὸς.
9. 46. *Χρ. Π.* 1571 δ' for τ'.
10. 56. *Χρ. Π.* 1603 ἐμὸς θίασος for θίασος ἐμὸς.
11. 116 sq. *Χρ. Π.* 1614 ἐν ᾧ θηλυγενὲς μένει γένος for ἔνθα μένει θηλυγενὴς ὄχλος.
12. 184. *Χρ. Π.* 1154 χρῆ for δεῖ. But δεῖ is the emendation of Musurus for δὴ of the MSS., which corruption had its origin doubtless in itacism.
13. 185. *Χρ. Π.* 1155 νῦν ἡγοῦ for ἐξηγοῦ.

14. 194. *Χρ. Π.* 1161 *ἀπόνως* for *ἀμόχθει*. This is plainly a change as the line is unmetrically constructed. Codex Vindob. (V.) gives *θ' ἀπόνως ἡμῶν ἡγήσαιτο*. A. and B. *ἡμῶν ἀπόνως ἡγήσεται*. The remaining *ὑμῶν ἀπόνως ἡγήσεται*.
15. 211. *Χρ. Π.* 228 *κἀγώ* for *ἐγώ*. Elsewhere the author of the *Χρ. Π.* has not been so particular about avoiding asyndeton.
16. 285. *Χρ. Π.* 569 *τοῦτο* V. B. D., ceteri *τούτου* for *τοῦτον*.
17. 444. *Χρ. Π.* 1386, 1929 *κἄδδησεν* for *κἄδησας*.
18. 448. *Χρ. Π.* 2072 *ἀνεῖσαν* for *ἀνῆκαν*.
19. 449. *Χρ. Π.* 1654 *θ'* for *δ'*. But V. reads *δ'*. Herwerden emended to *γ'*. Also *ἀνὴρ* for *ἀνὴρ*.
20. 472. *Χρ. Π.* 1549 *βροτοῖς* for *βροτῶν*.
21. 667 = 716. *Χρ. Π.* 2213 *δ'* for *τε* (667) or *τ'* (716).
22. 671. *Χρ. Π.* 2223 *τὸ τ' ὀξύθυμον* for *καὶ τοὐξύθυμον*.
23-24. 672. *Χρ. Π.* 2233 *πάντων* for *πάντως* and also *δί' ἐμοῦ* for *ἐξ ἐμοῦ*.
25. 713. *Χρ. Π.* 2218 *εἰσορῶν* for *εἰσιδὼν*.
26. 955. *Χρ. Π.* 1506 *κρύψει σὺ* for *κρύπτῃ δὲ*.
27. 1029. *Χρ. Π.* 649 *τί μηνύεις* for *τι μηνύεις*.
28. 1083. *Χρ. Π.* 2259 *ἐστήριξε* for *ἐστήριζε*. In the *Χρ. Π.* the verbs of the lines immediately preceeding and following are in the aorist. That may account for the change in this line. In Euripides the verb in 1082 is imperfect, in 1084 aorist.
29. 1087. *Χρ. Π.* 673 *κάρας* for *κόρας*.
30. 1091. *Χρ. Π.* 2015 *ὁρμήμασιν* for *δρομήμασι*. This may be due to the fact that *δράμωσι* already stands in the line in the *Χρ. Π.*
31-32. 1111. *Χρ. Π.* 1430 *θᾶσσον* for *θάσσων*. For the use of the adverb for the adjective in such expressions cf. examples 7 and 8 supra. Also *χαμαιριφὴς* for *χαμαιπετὴς*. MSS. A. and B. of the *Χρ. Π.* read *χαμαὶ ῥιφὴς*.
33. 1120. *Χρ. Π.* 2564 *οἴκτειρον* for *οἴκτειρε δ'*.
34. 1121. *Χρ. Π.* 2565 *ἀμπλακίαισιν* for *ἁμαρτίαισιν*.
35. 1147. *Χρ. Π.* 1300 *ὡς καλλίνικος, ἦ κλέος νίκης μέγα*. A. and B. have *εἰ*, with *ἦ* written above it in B. *εἴ* V. C. M. *ὅπου ἦ*, where *ὅπου* is plainly a gloss upon *ἦ*. P. of the Bacchæ reads: *καλλίνικον ἦ δάκρυα νικηφορεῖ*, which Kirchoff, Paley and Nauck retain. Reiske, followed by Hermann and Bruhn, reads *ὦ*, while Heath emends to *ἦ*, the reading adopted by Schœne and Wecklein. Emendations of *νικηφορεῖ*, which is a *ἅπαξ λεγ.*, have been suggested by Portus, *νίκη φορεῖ*, and Hartung, *νίκη φέρει*, the latter two adducing the line in the *Χρ. Π.* as partial evidence. In any case the

author of the *Χρ. Π.* has changed to all appearances hi Euripides.

36. 1150. *Χρ. Π.* 1145 *γὰρ* for *δὲ*.
37. 1163. *Χρ. Π.* 1052 *αἵμασι* for *αἵματι*.
38. 1213. *Χρ. Π.* 1263 *ἔμβαινε πηκτὰς κλίμακος πρὸς ἐμβάσεις* fo *πλεκτῶν πρὸς οἴκους κλιμάκων προσαμβάσεις*. The cor rection of *πλεκτῶν* to *πηκτῶν* has been spoken of o page 369. In this line *πρὸς ἐμβάσεις* is plainly a corruptio of *προσαμβάσεις*, which word the author of the *Χρ. Π.* ap parently did not understand. But the singular *κλίμακο* is either a variant reading or a deliberate change. Th singular *κλίμακος* with *προσαμβάσεις* is found in Aesch Sept. 466 and Eur. Phoen. 1173. More instructive is Phoen 489, where *πηκτῶν κλιμάκων προσαμβάσεις* is read, th two passages being plainly imitations, the one of the other This seems a strong argument against Doering's sugges tion that "*πηκτὰς* passt besser zu den Stufen oder Spros sen, als zu der Leiter."
39. 1216. *Χρ. Π.* 1485 *φέρωμεν* for *φέροντες*.
40. 1223. *Χρ. Π.* 2202 *εἴσω μολὼν* for *ἔσω βεβὼς*.
41. 1237. *Χρ. Π.* 163 *ἥξω* for *ἥκω*.
42. 1241. *Χρ. Π.* 167 *κυδρούμενος* for *γαυρούμενος*.
43. 1244. *Χρ. Π.* 1048 *ὦ μέγεθος* for *ὦ πένθος*. Here *πένθος* is restored by all the editors of the *Χρ. Π.* It is doubly strange that this corruption should have crept in, as it introduces a resolved foot, which, as we shall later see, the author of the *Χρ. Π.* plainly avoided. It seems probable that *μέγεθος* stood in his Euripidean MS.
44. 1245. *Χρ. Π.* 1049 *ἐξειργασμένοι* for *ἐξειργασμένων*. P. reads here *ἐξειργασμένῶν*. Probably the author of the *Χρ. Π.* did not understand the construction.
45. 1316. *Χρ. Π.* 1634 *θανὼν ἐμοὶ δ'* for *γὰρ οὐκέτ' ἂν*.
46. 1317. *Χρ. Π.* 1635 *ἀεί γ'* for *ἔμοιγ'*.
47. 1348. *Χρ. Π.* 2563 *ὀργὰν* for *ὀργὰς*.
48. 1354. *Χρ. Π.* 1702 *κἀγὼ* for *ἐγὼ θ'*.

To this list should be added the cases in which, to avoid a resolved foot, a change has been made by the author of the *Χρ. Π.*, which number 22, and are catalogued on pp. 376 sq.

In the following instances neither our MSS. nor the *Χρ. Π.* has preserved the correct reading.

1. 15 = *Χρ. Π.* 1589. *δύσχειμον*, corrected by Elmsley to *δύσχιμον*. This is explained by itacism.
2. 263 = *Χρ. Π.* 191. P. and C. *εὐσεβείας*, which Reiske corrected

to δυσσεβείας, a reading adopted by all. The *Χρ. Π* reads ἀσεβείας, which gives the right sense but is unmetrical.

3. 669 = *Χρ. Π.* 2220. τἀκεῖθεν, corrected by Brunck to τὰ κεῖθεν, due to the incorrect division into words.
4. 844 = *Χρ. Π.* 1287. P. εὐπρεπὲς corrected by Canter to εὐτρεπὲς. The *Χρ. Π.* has πανευπρεπὲς.
5. 854 = *Χρ. Π.* 2311. ὄφλειν, connected to ὀφλεῖν for Euripides. Cf. L. and S. sub voce.
6. 955 = *Χρ. Π.* 1506. P. κρυφῆναι. *Χρ. Π.* κρυβῆναι. Musurus corrected to κρυφῆναι for metrical reasons.
7. 1099 = *Χρ. Π.* 669 ἄλλοι, corrected by Brodaeus to ἄλλαι.
8. 1152 = *Χρ. Π.* 1147 χρῆμα. But Orion, Anth. IV. 55, reads κτῆμα, which all editors adopt.
9. 1162 = *Χρ. Π.* 1051. P. γόνον. *Χρ. Π.* θρῆνον. Canter changed to γόον. It is possible that the *Χρ. Π.* may be right here.
10. 1355 = *Χρ. Π.* 1670. P. ἔτι δέ μοι τὸ θέσφατον. *Χρ. Π.* ἔστι γὰρ τὸ θέσφατον. It seems likely that the author of the *Χρ. Π.* found in our Euripidean MS. what our MS. now contains, but changed to obtain a verb and to avoid the tribrach. Haupt suggested μοὐστὶ, which all the editors have adopted.
11. 1368 = *Χρ. Π.* 1706. πατρῴα, changed by Elmsley to πατρία *metri causa.*

It remains now to sum up our discussion of the value of the citations from Euripides found in the *Χρ. Π.* If we have correctly classified the citations the conclusion is evident. In 14 instances the *Χρ. Π.* has furnished us the means of correcting our MSS., of which three instances only are from that portion of the play contained in the two MSS. The *Χρ. Π.* has not preserved the exact form of the word in all cases, nor have all, or even the best MSS. of the *Χρ. Π.* preserved the correct reading in every case. The benefit of the doubt has been given the *Χρ. Π.*, so that cases 13 and 14 have here been included, and case 11, although testified to by only one MS., and that not the best one. In our second list are to be found 6 cases in which the excellence of the readings of the *Χρ. Π.* is by no means so clear as to recommend their adoption to all the editors of the Bacchæ. In four cases the *Χρ. Π.* stands in agreement with one MS. and not the other, in two of which there may be serious doubt, if the reading of the *Χρ. Π.* is preferable. However, to be perfectly fair and just to the *Χρ. Π.*, these cases may be all enumerated in its favor, and the sum total is 24, over against which should be placed the 48 + 22 = 70 cases in which the author of the *Χρ. Π.* has without any doubt and for no good reason changed the reading of the Euripidean text, or found a very corrupt form of the Euripidean text in his MS. In the following it will

be shown that the writer of the *Χρ. Π.* was apparently exceedingly faithful to his Euripidean text, and changed it, in all probability, only to avoid having more than twelve syllables in his line, and that in consequence his text of the Bacchæ was of a most corrupt nature. If this is substantiated then it is difficult to place any reliance upon the evidence of the *Χρ. Π.*, so far as the text of the Bacchæ is concerned. If, then, this be the truth in the case of the Bacchæ, where the Euripidean MSS. are so poor, the testimony of the *Χρ. Π.* for plays contained in better MSS. will be proved to be almost unworthy of consideration.

That the author of the *Χρ. Π.* followed his text of Euripides faithfully, even slavishly, is evident from the following considerations:

1. The retention of the Doric forms of choral passages. Such are *βιοτάν* of 1140 = B. 73 and *ψυχάν* of 1141 = B. 75. In only one instance is this neglected. In 1801 *τῆς* is written, where Bacchæ 389 shows *τᾶς*, which change is easily explained as due to the effect of the added word *καλῆς*.

2. Line 1099 is very instructive as to the fidelity of the author of the *Χρ. Π.* to his Euripides and also of the liberty he allowed himself with the text. Bacch. 993 = 1013 reads, *ἴτω δίκα φανερός, ἴτω ξιφηφορος*, a trimeter although in a choral passage. This contained a resolved foot, which was an offense to the writer of the *Χρ. Π.* His version is, therefore, *ἴτω δίκ', ἴτω φανερῶς ξιφηφόρος*, where he has preserved the Doricism *δίκα*, but treated the final vowel as short and subject to elision. He would certainly never have attempted to elide an *-η*, had he found that in his MS. of the Bacchæ, so that we may regard the Doric form preserved in this instance also.

3. In 1150 = B. 180, although the author of the *Χρ. Π.* has added to the sentence the three last words of 1149, while Euripides connected their equivalent with the preceding line and began a new sentence with this one, the *Χρ. Π.* shows the *δ'* retained from Euripides, although now the fifth word in its sentence.

In 1594 codex V. has preserved *ἔχουσα* (nom.), though the construction demands the accusative, and the other MSS. have the accusative, *ἔχουσα* being the form found in the Bacchæ 19. Perhaps this is to be regarded rather as an error of V. than as the retention of the Euripidean reading, although in several instances V. has preserved the better readings. Cf. Brambs' praefatio to his edition, p. 5.

4. The preservation of resolved feet. It has already been pointed out in several instances that the author of the *Χρ. Π.* has taken the liberty of changing the Euripidean text to avoid a resolved foot. It remains to be shown how far this influence has been at work in the *Χρ. Π.* Before giving the complete list of cases, a few deserve special mention, as being very instructive of the method taken by this writer. The simplest way to avoid a resolved foot was to omit a word from the line. This has taken

place in 168 = B. 1242 where γάρ has been dropped to obtain a twelve syllabled verse: καλεῖ φίλους εἰς δαῖτα· μακάριος εἶ for μακάριος γὰρ εἶ, in which the first α and the ι of μακάριος receive the accent, although short in quantity. Again 1589 = B. 15. Here τε has been dropped, thus Βάκτρια [τε] τείχη τήν τε δύσχειμον χθόνα, where ι of Βάκτρια receives the accent.

A second way to avoid the tribrach was to combine with the omission or elision of a syllable transposition. Thus 2007 = B. 692. αἷδ' ἀποβαλοῦσαι τὸν ὕπνον ὀμμάτων from αἱ δ' ἀποβαλοῦσαι θαλερὸν ὀμμάτων ὕπνον. Here are three violations of the rules for quantity, in the two αs of ἀποβαλοῦσαι and the υ of ὕπνον. In 1099 the remarkable elision of Doric α has been noted on p. 376. In 1592 = B. 17, the Χρ. Π. reads πᾶσαν τ' Ἀσίαν κτλ. for Ἀσίαν τε πᾶσαν κτλ.

Then again a change of words could be made. Thus 2223 = B. 671 τὸ τ' ὀξύθυμον καὶ τὸ λίαν ἠρμένον for καὶ τοὐξυθυμον καὶ τὸ βασιλικὸν λίαν, where ι of λίαν is lengthened. And 1566 = B. 49. οὗ διαθεὶς τἀνθένδ', ἀναστήσεις κράτος for τἀνθένδε θέμενος εὖ, μεταστήσω πόδα. An interesting example is 1054 = B. 1260 εἰ δ' ἕως τέλους for εἰ δὲ διὰ τέλους.

These cases will suffice for illustration. The remainder are: 569 = B. 285; 1310 = B. 1280; 1536 and 1543 = B. 54; 1564 = B. 22; 1570 = B. 45; 1583 = B. 8; 1590 = B. 16; 1593 = B. 18; 1603 = B. 56; 1683 = B. 1335; 1754 = B. 1339; 2075 = B. 447; 2519 = B. 60; 2560 = B. 1345. In most of these cases short vowels have been lengthened to receive the accent. Adaptation of lines written in other metres are full of the same sort of errors. Cf. 653 = B. 1041; 1052 = B. 1163; 1706 = B. 1368.

Further when the author of the Χρ. Π. found it necessary for his theme to change the Euripidian text, he avoided the use of a resolved foot, where the Euripidean equivalent has such. The following are the instances: 169 = B. 1243; 666 = B. 1095; 668 = B. 1097; 1152 = B. 181; 1153 = B. 183; 1156 = B. 186; 1161 = B. 194; 1525 = B. 963; 1552 = B. 31; 1553 = B. 29; 1602 = B. 55; 1668 = B. 492; 1760 = B. 1332; 1790 = B. 362; 1811 = B. 733; 1835 = B. 684; 2074 = B. 446; 2280 = B. 790; 2520 = B. 61. In many of these cases a short α is lengthened under the influence of the accent.

But to return to our point. In four instances the author of the Χρ. Π. has retained unwittingly, it would seem, a resolved foot, indicating how carefully he followed his Euripidean MS. When off his guard he followed his model and allowed a line to him metrically objectionable to creep in in its exact form. When he has tried to remove the source of objection he has betrayed himself by his absolute ignorance and disregard of the laws of quantity. The instances referred to are as follows: 1585 = B. 10. Here the MSS. C., M., A., B. read with Euripides αἰνῶ δὲ κρίσιν [Eur. Κάδμον] ἄβατον ἢ [Eur. ἃς] πέδον τόδε. Both Dübner and

Brambs reject δὲ from the text but wrongly. We have simply caught him napping here and have an insight into his method of work.

1570 = B. 45 ἢ [Eur. ὃς] θεομαχεῖ τὰ κατὰ σε σπονδῶν τ' ἄπο [Eur. κατ' ἐμὲ καὶ σπονδῶν ἄπο.] Here θεομαχεῖ was left in C., M., V. and the other resolved foot removed. It may be that this is to be explained by synizesis, as in A., B. it appears written θυμαχεῖ.

2219 = B. 668 θέλω δ' ἀκοῦσαι, πότερά σοι παῤῥησία. This is the reading of all the MSS. except A. (πότερ' ὡς παῤῥ.) and V. (πωτερον παῤῥ.), which are evidently attempts to remove the objectionable foot.

1048 = B. 1244. This has been discussed on p. 374. It seems most probable that he found in his Euripides μέγεθος.

We have then shown how the author of the *Χρ. Π.*, when off his guard, followed his MS. of the Bacchae so closely, that he has introduced resolved feet in several instances, and also that the writer allowed himself the liberty to change a line to remove the objectionable tribrach. The conclusion must be drawn, that for Euripidean lines containing resolved feet the *Χρ. Π.* offers in all but a very few instances testimony of a very insignificant value. We have also demonstrated how slavishly in several instances he has followed his model to the sacrifice of grammatical and orthographical accuracy in his own composition. We feel, therefore, justified in affirming, that, inasmuch as in 48 cases he has preserved readings vastly inferior to those of our own MSS., cases in which a change is scarcely to be justified, the writer of the *Χρ. Π.* made use of a MS. of the Bacchae that contained a very corrupted text of that play. I cannot in view of facts here brought together agree with Dœring that the citations from the Bacchae in the *Χρ. Π.* have a high value for the text criticism of that play. Nor can I give assent to his statement, that the Euripidean MS. used by this writer should be placed for its excellence midway between the two classes of the Euripidean MSS. distinguished by Kirchhoff. The result of the present investigation has been to assign to a class much inferior to the existing MSS., which belong to Kirchhoff's second class, the MS. of the Bacchae that the author of the *Χρ. Π.* has used. Probably a careful investigation of the subject through the other plays of Euripides plundered by this ignorant writer would reveal the same state of affairs there also.

LIST OF CRUSTACEA CLADOCERA FROM MADISON, WISCONSIN.

By E. A. BIRGE,

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In 1878 the writer published Notes on Cladocera in the fourth volume of the Transactions of this Academy,* in which were noted twenty-five species of Cladocera found at Madison. Returning to the subject with better means of collecting and a much larger command of the literature of the group, I have been able to enlarge greatly the number of species and to identify them more accurately. As the task of reviewing the greatly scattered literature, especially of the *Lynceidæ*, seems likely to occupy some time, it seems advisable to print a list of the species already found, with notes on rare or new forms.

A glance at the subjoined list of sixty-four species and varieties regarded by many European writers as species, will show how close our fauna is to that of Europe. Out of the whole number, only nine are peculiar to this country and of these five are varieties of species found elsewhere, or are very close to foreign species. Three species are determined as new, *Latonopsis occidentalis* from the *Sididæ*, *Moina sp. nov.* from the *Daphnidæ*, *Alona lepida* from the *Lynceidæ*.

With the exception of five species and varieties (*Daphnia pulex*, *D. retrocurva*, *Alona tenuicaudis*, and the species of *Moina*), all of the species in the list have been found in Lake Wingra. This is a small lake about one and three-fourths miles long and half as wide, with broad margins of marsh all around it. In the marsh the water is from a few inches to two feet deep between the areas of wild rice and reeds, and the bottom is partly composed of vegetable débris and partly covered by a dense growth of *Chara*. The lake itself hardly exceeds fifteen feet in depth, and almost the entire bottom is overgrown with water plants of various kinds. Among these weeds and in the marshes Cladocera abound. The abundance of food and variety of locality offered probably account for the great number of species. In Lake Mendota, a much larger body of water, six miles by four, and having a depth of sixty to eighty feet, I have found only thirty-eight species of Clado-

* Vol. IV, 1876-7 (printed 1878), pp. 77-110. Pl. I, II.

cera. Doubtless more careful and prolonged collecting would disclose new species in both bodies of water, but the larger lake is certainly poorer in number of forms, especially the littoral species. The pelagic forms are, of course, more abundant in the larger lake, and one variety has been found in Lake Mendota which Lake Wingra does not possess.

This single locality has yielded a number of species, comparing not unfavorably with the fauna described from England, Denmark or Russia. No European country shows more than 100 species; so that more than one-half of the probable fauna of Wisconsin has been found here. That so large a fraction of the entire fauna should belong to one locality will not appear strange when the similarity of the fauna to that of Europe is considered. If the species of Cladocera have so wide a range as appears from Sar's observations on Australian Cladocera, and from my work here, it is not probable that many species are strictly local. We should expect to find any given species over a large extent of country in suitable localities. This expectation has been realized in many cases. As conspicuous instances I may note the occurrence of *Drepanothrix dentata*, Eurén, in Wisconsin, the finding of *Dunhevedia setiger*, Birge, in Hungary by Daday, and the occurrence of *Ilyocryptus longiremis*, Sars, in Wisconsin and in Australia. No doubt some species are strictly local, confined to a small area, or the product of life-conditions existing there and not elsewhere. But the chance that this is true in any given case is small, and all well marked species should be looked for in every suitable locality. We should expect also that a locality especially favorable to the development of the Cladocera would contain a very large fraction of the fauna of the region.

The subjoined list also shows the value of long and careful collecting in one locality, and the impossibility of justly estimating the Cladocera of a lake from a single visit. The different forms behave much like the plants of a locality. Some species are present throughout the season. Some can be found only for a few days. Some come in the spring and disappear early, while others belong to the latter part of the open season. Of the nearly sixty species found in Lake Wingra I have never found more than thirty as the result of a single day's work. It is clear that a list of Cladocera compiled from a flying visit to a locality and containing from six to twenty species, has no claim to represent the fauna of that locality. Only careful collecting at intervals throughout an entire season can give even an approximate idea of the number of species present.

I may add that a single specimen was found in Lake Wingra, belonging to the genus *Anchistropus*, Sars, and apparently not to the species *emarginatus*, Sars. It was accidentally destroyed before it could be carefully studied.

LIST OF CLADOCERA FOUND AT MADISON, WISCONSIN.

1. *Holopedium gibberum*, Zad.
2. *Sida crystallina*, O. F. M.
3. *Daphnella brachyura*, Liév.
4. *Daphnella brandtiana*, Fisch.
5. *Latona setifera*, O. F. M.
6. *Latonopsis occidentalis*, spec. nov.
7. *Moina brachiata*, Jur.
8. *Moina*, spec. nov.
9. *Simocephalus vetulus*. O. F. M.
10. *Simocephalus serrulatus*, Koch.
11. *Ceriodaphnia megops*, Sars.
12. *Ceriodaphnia reticulata*, Jur.
13. *Ceriodaphnia pulchella*, Sars.
14. *Ceriodaphnia consors*, Birge.
15. *Scapholeberis aurita*, Fisch.
16. *Scapholeberis obtusa*, Schdl.
17. *Scapholeberis mucronata*, O. F. M.
18. *Daphnia pulex*, De Geer.
19. *Daphnia Schoedleri*, Sars.
20. *Daphnia minnehaha*, Herrick.
21. *Daphnia hyalina*, Leydig.
22. *Daphnia kahlbergensis*, Schoedler.
23. *Daphnia kahlbergensis*, var *cederstroemii*, Schdl.
24. *Daphnia kahlbergensis*, var. *retrocurva*, Forbes.
25. *Lathonura rectirostris*, O. F. M.
26. *Macrothrix rosea*, Jur.
27. *Macrothrix laticornis*, Jur.
28. *Drepanothrix dentata*, Eurén.
29. *Ophryoxus gracilis*, Sars.
30. *Ilyocryptus sordidus*, Liéven.
31. *Ilyocryptus longiremis*, Sars.
32. *Bosmina longirostris*, O. F. M.
33. *Bosmina longicornis*, Schoedler.
34. *Bosmina cornuta*, Jur.
35. *Bosmina bohemica*, Hellich. (?)
36. *Eurycercus lamellatus*, O. F. M.
37. *Leydigia quadrangularis*, Leydig.
38. *Alona quadrangularis*, O. F. M.
39. *Alona affinis*, Leydig.
40. *Alona lineata*, Fischer.
41. *Alona guttata*, Sars.
42. *Alona costata*, Sars.
43. *Alona tenuicaudis*, Sars.
44. *Alona lepida*, spec. nov.
45. *Graptoleberis testudinaria*, Fischer.
46. *Dunhevedia* (*Crepidocercus*) *setiger*, Birge.
47. *Pleuroxus trigonellus*, O. F. M.
48. *Pleuroxus denticulatus*, Birge.
49. *Pleuroxus gracilis*, Hudendorff, var. *unidens*, Birge.
50. *Pleuroxus exiguus*, Lillj.
51. *Pleuroxus excisus*, Fischer.
52. *Pleuroxus procurvatus*, Birge.
53. *Chydorus sphaericus*, O. F. M.
54. *Chydorus sphaericus*, var. *caelatus*, Schdl.
55. *Chydorus sphaericus*, var. *punctatus*, Hellich.
56. *Chydorus globosus*, Baird.
57. *Alonopsis latissima*, Kurz.
58. *Alonopsis media*, Birge.
59. *Acroperus leucocephalus*, Koch.
60. *Camptocercus macrurus*, O. F. M.
61. *Camptocercus rectirostris*, Schdl.
62. *Camptocercus biserratus*, Schdl.
63. *Polyphemus pediculus*, De Geer
64. *Leptodora hyalina*, Lillj.

NOTES ON THE PRECEDING LIST.

Species 1. HOLOPEDIUM GIBBERUM, Zad.

I have found this species only once in Madison. It is quite abundant in collections from northern Minnesota, and Forbes* notes its occurence at Grand Traverse Bay, Lake Michigan.

Species 2. SIDA CRYSTALLINA, O. F. Müller.

No specimens were found belonging to the form *S. elongata*, DeGeer.

Species 3 and 4. DAPHNELLA BRACHYURA, Liév. and D. BRANDTIANA Fisch.

Of those closely allied forms I have only to say that both are found with us, and show exactly the same differences as described and figured by Sars in his *Norges Ferskvandskrebsdyr. D. brachyura* is usually found in open water, and *D. brandtiana* in marshes. I cannot state this as a law, however, as both forms are found together sometimes, in either kind of locality.

Species 5. LATONA SETIFERA, O. F. Müller. Plate XIII. Fig. 6.

Our specimens of Latona have one peculiarity not mentioned by any European writer. There is a thick coat of short hairs on the head, body and antennæ. These hairs are .02 mm. or less in length, are close set and give the outline a velvety appearance when seen by transmitted light. P. E. Müller † says: "Hvad der er aldeles eiendommeligt for Latona og neppe jagttaget hos nogen anden Cladoceer, eret fint Lod af ganske korte Haar, der isaer findes over Matrix; det er vanskeligt at see og opdages kun ved staerkt Sidelys." This exact account shows that his specimens were not villous as ours are. The hairs are conspicuous in any light and are very easily seen. No other European writer mentions a similar structure. A more extended study of specimens from different localities will show whether this is a local peculiarity or is characteristic of a distinct variety. On old females which have not moulted recently the hairs are worn off.

The male antenna differs somewhat from the account given by Sars.‡

The *appendix ciliata* is much larger than Sars figures it, and is situated at the same level as the sense-hairs instead of distal to them. The size, number and arrangement of the setæ on the edge of the carapace differ from the details given by Sars, but not in any very important respect.

Latona seems to be rare in Europe, but the apparent rarity is, as Sars says, probably due to its mode of life and the method of collecting. In late summer and early fall, one can be certain of obtaining a good num-

* Forbes, S. A. On some Entomostraca of Lake Michigan and adjacent Waters. Am. Naturalist, vol. xvi., p. 641. Aug., 1882.

† Müller, P. E. Danmarks Cladocera. pp. 97-98.

‡ Norges Ferskvandskrebsdyr, p. 55, Pl. III, figs. 17a, 17b.

ber at various localities near Madison. It lives in clear water among weeds, and a dredge which can be dragged *through* the weeds and not merely *above* them is needed in order to secure it. With the cone-dredge it is not difficult to obtain 20 to 100 specimens. The same may be said of such bottom forms as *Ophryoxus* and *Drepanothrix.*

Sars speaks feelingly of the difficulties which beset one who attempts to view this powerful and obstinate cladoceran from the side. If a life-box is used and a trace of ½ per cent. of solution of osmic acid in water is added to the water containing the animal, there will be little trouble in turning it on its side. After the poison begins to act, it is best to attempt turning the animal by rotating the cover of the life-box. If left to die undisturbed the antennæ are usually expanded while an irritation applied to it while alive causes it to fold the antennæ along its sides, when it can readily be turned into any position.

Species 6. LATONOPSIS OCCIDENTALIS, sp. nov. Plate XIII. Figs. 1–5.

In 1888 G. O. Sars* established the genus and species *Latonopsis australis* for a new form of the *Sididæ* raised by him from mud obtained from Australia. I have found here a second and closely allied species of this new and remarkable genus, and have succeeded in finding males which did not develope in Sars' aquaria.

Latonopsis, Sars, is closely alled to *Latona*, Sars, and may be characterized as follows:

LATONOPSIS, Sars.

Impression between head and thorax slight or wanting. Labrum devoid of plate-like expansion. Antennule with a long, plumose, straight or curved flagellum, articulated to the basal part. Antenna with simple rami, the superior ramus bi-articulate, the inferior tri-articulate, as in *Daphnella.* Heart concave dorsally, truncate anteriorly, the aorta arising on the ventral side. Shell-gland with three long branches. Male (of *L occidentalis*, Birge, at least) with simple copulatory organ, and hook on first leg. Antennule long, slightly curved, armed with fine teeth resembling in general the antennale of *Sida*, but having a median projection near the base. Color of both species yellowish-transparent.

SPECIES.

a. Fornices absent. Antennule shorter than anterior margin of head. *L. australis*, Sars.

b. Fornices present. Antennule longer than anterior margin of head. *L. occidentalis*, sp. nov.

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* Sars, G. O. Additional notes on Australian Cladocera raised from Dried Mud. Christiania 1888, pp. 6–15. Pl. I. Christiania Videnskabs Selskabs Forhandlinger 1888. No. 7.

DESCRIPTION OF FEMALE.

Length up to 1.8 mm. but usually smaller.

Measurements of average specimens.	♀ mm.	♂ mm.	♂ mm.
Length	1.30	.82	.61
Height	.80	.40	.27
Antennule	.42	.35	.28
Abdominal setæ	.50	.41	.31
Longest spine on carapace	1.05	—	.50

The head is in some cases marked off from the body by a slight depression, not seen in young specimens, and often absent in older individuals. The anterior outline of the head as seen from the side forms a straight or slightly convex line from the attachment of the antennules to the eye, where it passes by an abrupt curve into the dorsal margin. This margin is frequently continuous to the hinder end of the valves, and is nearly straight in young specimens but strongly convex in old females. Ventrally the anterior margin of the head terminates in a small projection to which the antennules are attached. The ventral margin is continued into the labrum, and is entirely devoid of the leaf-like expansion characteristic of *Latona*, Sars' *organum affixionis*. Above the insertion of the antennæ the valves are continued into small bilobed fornices, resembling those of *Latona* but much smaller, and not continued to the insertion of the antennules as are those of *Latona*. The head as seen from above is somewhat pyramidal in form.

The carapace does not differ greatly from that of the *Sididæ* in general. It leaves the oral structures uncovered in front; it is straight or convex dorsally according to the age of the animal; the ventral margin is evenly rounded and passes into the nearly straight posterior margin by a curve which forms no marked projection. The upper posteal angle is well marked. The edge of the carapace is fringed with long plumose setæ, each set on a small elevation. At the lower posteal angle are placed three setæ, much longer than the others. They are often longer than the carapace, and diverge from each other as they leave the shell, one passing nearly straight backward and the others more outward. These setæ are longer in our species than in *L. australis* as figured by Sars. The valves are not marked except by the braces (Stützbalken).

Along the inside of the hinder edge of the shell, from the insertion of the long setæ to the junction of the valves, runs a row of fine spines like those of *Latona*.

APPENDAGES.

The antennule consists of the basal part, the sense-hairs and the flagellum. The first is short, oblong, freely movable. The sense-hairs num-

ber about eight and are placed on the posterior side of the distal end of the base. The flagellum is attached to the base with a distinct suture. Sars calls it "distinctly articulated" in *L. australis*. Whether he means that there is a movable joint he does not make clear. In *L. occidentalis* there is simply a distinct suture. The flagellum is long, curved backward, tapers to a fine point, and is fringed with long straggling sense-hairs. These are far less numerous than in *Latona*. Most of them are on the anterior side of the antennale but at the tip they are attached to all sides. In this arrangement of the hairs the structure differs from the antennule of *L. australis* as figured by Sars. The sense-hairs are also longer than he shows them and the whole antennule is about twice as long, relatively, as that of *L. australis*.

The antenna closely resembles that of *L. australis*. The basal joint is exceedingly stout, so that the branches look too small for it. The dorsal sames is bi-, the ventral tri-articulate. The setæ are $\frac{4\ (5) - 7}{0 - 1 - 4}$ and the spines $\frac{1 - 1}{0 - 1 - 0.}$ The basal joint bears the usual dorsal sense organ at the base, and at the distal end are a spine anteriorly and a plumose sense-hair behind. The proximal joint of the dorsal ramus bears four well developed setæ, and sometimes a fifth, proximal, seta which is much smaller than the others. Its presence or absence seems to depend on no law, as it is either present or absent in specimens of all ages and both sexes and may be present on one side and absent on the other side of the same individual. All setæ are two jointed and densely plumose.

The proportionate length of individual setæ differs in my specimens from *L. australis* as figured by Sars. The terminal setæ of the dorsal ramus are little longer than the others in *L. occidentalis*. The seta of the second joint of the ventral ramus is as long as the largest on the distal joint and each is quite twice as long as any other seta on the branch.

The post-abdomen closely resembles that of *L. australis*. It is short, fleshy, obtusely conical, and armed with nine very small super-anal denticles. The abdominal setæ are two-jointed, plumose, each set on a fleshy projection. They are a little longer than those of *L. australis*. The terminal claws are strongly curved, and have two secondary teeth, of which the distal is the longer.

The mouth parts and legs seem to resemble closely those of the other *Sididæ*. No careful study of the legs, has, however, been made. They number six pairs, as in other *Sididæ*.

INTERNAL ORGANS.

In the structure of the internal organs *L. occidentalis* agrees closely with *L. australis*, and I can add little to Sars' account. The general arrangement of the organs of the head may been seen in the figures.

The heart as seen from the side, shows a tube convex below and concave above. It is truncated anteriorly, and the aorta issues from its ventral side. From above the heart closely resembles that of *Latona*, having the form of a broad sac, rounded behind, and widest through the venous ostia.

The shell-gland has a form in this genus, which is unique among the Cladocera. It consists of three branches, of which the shortest is dorsal and extends toward the heart, the next in length is ventral, while the longest extends posteriorly and may reach through two-thirds of the length of the valve. This last loop is found only in *Latonopsis*. The whole gland consists of a tube doubled on itself, whose course can easily be traced. Beginning near the mandible in a bladder-like expansion the tube passes into the valve and extends ventrally; it returns on itself to the middle point, then passes backward in a long loop, returns again to extend up toward the heart and come back to the middle. Then comes a second posterior loop, lying parallel to and within the first, and on its return the tube passes to its outlet near the mandible. Thus there are two passages in the dorsal and ventral loops and four in the posterior, not three as stated by Sars (op. cit. p. 9.). Sars' figure (Pl. I, Fig 1.) shows the organ quite correctly.

DESCRIPTION OF MALE.

The male resembles in general the young female.

The antennules are long and stout, being often nearly half as long as the animal. They taper toward the apex, are curved, but not geniculate. They are provided with a long row of very fine teeth extending from a point near the sense-hairs to the apex. They thus resemble in general the antennule of the male *Sida* and *Daphnella* and differ widely from the male *Latona*. Near the base of the antennule on the inner side is a stout projection, rounded at the apex and covered with very fine hairs. This projection is probably equivalent to the "appendix ciliata" of the male *Latona*.* In *Latona*, Sars shows the appendix ciliata some way distal from the olfactory hairs, while in *Latonopsis*, it is some way proximad to these. My specimens of *Latona*, however, show the appendix close the to sense-hairs; so that the difference of position does not interfere with homology. The cilia on the appendix of *Latonopsis* are very fine and easily overlooked; they are far less conspicuous than in *Latona*.

The copulatory organs resemble those of *Latona*. They are a pair of long, curved, flexible appendages, perforated by the vasa deferentia. They arise at the base of the post-abdomen and are long enough to reach beyond the terminal claws.

The first leg shows a very distinct and strong hook. In this structure *Latonopsis* differs from the other *Sididæ* and especially from *Latona*.

* Sars, G. O. Norges Ferskvandskrebsdyr. Cladocera Ctenopoda, p. 55. Pl. III, Fig. 17.

Sida, *Limnosida* and *Daphnella* have short, fleshy knobs rather than hooks, and *Latona* is devoid of any special structure. *Holopedium* has a hook similar to that of *Latonopsis* but much longer, as is natural in that genus.

The new hatched male has the copulatory organ in the form of a pair of small buds, which do not reach the adult form until after four or five moultings. The antennule of the young male differs widely from the adult form. It is short, lacks the appendix ciliata, and shows a distinct suture between base and flagellum. The latter is covered with long straggling hairs. The whole structure closely resembles the female antennule. It is clear that the extension of the male antennule beyond the sense-hairs in the homologue of the flagellum of the female.

RELATIONS OF THE GENUS.

Sars was entirely justified in separating *Latonopsis* from *Latona*. While the structure of the two genera is quite similar in the female, the male differs widely from that of *Latona*. The antenna is more like that of *Daphnella* than that of any other genus, especially in the rami, while the great development of the base is like that of *Latona*. The antennule is peculiar and shows an intermediate stage between that of *Latona* and *Daphnella*, though nearer the former. In the male, however, the antennule is more like that of *Sida* than that of *Latona*. In the form of the body, the outline of the head, in the fornices, the position of the eye, eye-muscles and optic ganglion; in the heart; in the shape of the carapace, and the development of the setæ of the carapace, it approaches *Latona*. It lacks entirely the peculiar development of the antenna seen in *Latona* and the plate on the lower side of the head; while *Latona* lacks the development of the shell-gland, which *Latonopsis* shows. In most of the points of resemblance and difference between the two genera, *Latonopsis* is nearer the ordinary form of the *Sididæ*, and it may be considered as connecting *Latona* with the other *Sididæ*, but with many cross-relations to other genera.

RELATIONS OF THE TWO SPECIES.

L. occidentalis is very close to *L. australis*. Indeed, I am not sure but that they are really the same species. There are many points of minor difference, but the most tangible is the antennule, which is about twice as long in the American form. It must not be forgotten, however, that Sars' specimens were hatched from mud, and it may be possible that specimens collected in their native waters will agree more closely with the American species. If the difference is constant, *L. australis* is nearer the ordinary type of the *Sididæ* in the structure of the antennule.

BIOLOGICAL REMARKS.

Latonopsis occidentalis was found in Lake Wingra, a small lake about one and three-fourths miles long with a broad margin of marsh. It lives chiefly in the marshy region although I have found it in deeper water—one to three meters. It is most abundant in openings among the reeds of the marsh, where there is a foot or so of water filled with algæ and vegetable débris. In one such spot it was especially abundant during the summer of 1891. A single haul of the dredge would give from six to thirty individuals. I have dredged it with *Latona* in the open water, while I have never found *Latona* in the marsh. Sars' specimens came from a clayey mud. I have never found this species in muddy water.

In the aquarium it behaves quite like *Latona*. It often remains suspended and motionless in the water, and can often be turned over with the dropping tube without disturbing it. When, however, it decides to move it starts very suddenly. Its movements are less vigorous than those of *Latona*, as would be inferred from the different structure of the antennæ.

I have never seen more than eight young in the brood cavity. There are two sexual eggs, for whose reception a special cavity is enclosed, although there is no true ephippium.

The males appear in the latter part of July and the first part of August, and in September no specimens of either sex could be found, while *Latona* was more plentiful at this time than earlier in the season. Constant observation at any small lake will convince the student that the appearance of the males does not depend on temperature or any other simple cause. Each species has its own time for sexual reproduction, which is related to external influences in the same complex way as is the flowering of plants.

Species 8. MOINA, spec. nov.

A species of *Moina*, apparently new, has been found, but it is not as yet thoroughly worked up and will probably form the subject of a special paper. It seems related to *M. brachiata*, Jur. and was at first identified with this species. Further study, however, showed that there was only one egg in the ephippium and that the structure in other particulars differ from *M. brachiata*. The male especially shows peculiarities not found in other species.

Species 21. DAPHNIA HYALINA, Leydig. Plate XIII. Fig. 9.

Into this species have been united *D. galeata*, Sars, *D. pellucida*, P. E. Müller and *D. gracilis*, Hellich. Two well marked varieties are found at Madison. One with pointed crest is found in Lake Wingra, and the other whose crest is rounded is found in the larger lakes. Although the

lakes are only a mile apart, I have not found the pointed variety in Mendota or the rounded in Wingra. The outlines of the head are very variable, the variations quite closely resembling those represented in *D. berolinensis*, *apicata*, and *cucullata*, although of course this species has the macula nigra.

The males appear in the latter part of September. The flagellum of the antennule is convex, stout and short, usually little longer than the sense-hairs. The anterior sense-bristle in our specimens lies little nearer the end of the basal portion of the antennule than the head. In this our specimens differ from Eylmann's * description, who says of it, that it is "von der Endborste nicht weit entfernt."

This species is the most abundant in the open waters of the Madison lakes. I have also obtained it from Minnesota and Michigan, showing some variation from our form in each case.

Species 24. D. KAHLBERGENSIS var. RETROCURVA, Forbes. Plate XIII. Figs. 7, 8.

This form was first described by Forbes * as a distinct species. It is the most extreme Daphnid form yet observed. I cannot agree in the statement of Forbes that the large helmeted forms predominate in the smaller lakes (l. c. p. 643.) At Madison the forms of *D. hyalina* and of *D. retrocurva* in Lake Mendota are much more helmeted than those in Lake Wingra. The former lake is about six miles by four, the latter 1¾ by ¾ mile. *D. hyalina* in the smaller lake is more like *D. apicata*, while in Mendota the crest is more developed than is shown by any European descriptions. *D. kahlbergensis* from Wingra shows the forms typical of that species and of *cederstroemii* while the full development of the crest only comes in the larger lake. The males of this species appear late in the fall, in the latter part of October and in November. The head is of the *kahlbergensis* type, sometimes curved up but never showing the extreme development of the female. The antennule has a flagellum a good deal longer than the sense-hairs, curved at the tip and distinctly articulated to the basal part.

Our specimens do not show the extreme development of the head before birth noted by Forbes (l. c., p. 642). The head in the young is not as much crested as in the adult *D. hyalina*. This species is always found in company with *D. hyalina* and is far less numerous. On calm summer nights the water of Lake Mendota swarms with these two species, together with a *Cyclops*, a *Diaptomus*, and *Leptodora hyalina*. They are not abundant close to shore and seem to spend the day in swarms at the

* Eylmann, E. Beitrag zur Systematik der Europäischen Daphniden, Freiburg i. B. 1886, p. 33.

* Forbes, S. A. Entomostraca of Lake Michigan and adjacent waters. American Naturalist. Vol. xvi., p. 642, August, 1882.

bottom where the vegetation consists mainly of diatoms, outside of the growth of weeds. The number of the Cladocera is simply incalculable. I do not think that any shallow water is more filled with crustacean life than are the open waters of our lakes. Dredging does not give a fair idea of the number of open water individuals. Only surface collecting at night will disclose them.

Species 26. MACROTHRIX ROSEA, Jurine. Plate XIII. Figs. 13, 14.

I have succeeded in finding several specimens of the male of this species and have materially increased the accuracy of my knowledge of its structure. I found a single male in 1877 which was described in the Transactions of the Wisconsin Academy, Vol. IV. p. 90. Since that time the male has been seen by Daday,* who gives a figure which, however, is so small and shows so little detail that it does not add much to our knowledge.

The male antennules are long and curved, provided with a long anterior sense-hair at the base. They are curved toward the median plane of the body at the tip and bear the olfactory hairs on a small elevation on the anterior side. On the posterior side of the apex is a cluster of 5-6 long diverging sense-hairs. Daday shows these in his figure, but does not mention them in the text. In the possession of this extra sense organ, the male *M. rosea* differs from all other male Cladocera known, including the closely allied *Macrothrix laticornis*. These sense-hairs were not seen by me in my earlier specimen.

The post abdomen is prolonged into a flexible projection, on whose summit the vas deferens opens, just before the very small terminal claws. The whole structure thus resembles that of the male *Bosmina*.

Species 27. MACROTHRIX LATICORNIS, Jurine.

This form, which is usually given as the commonest of European species seems very rare here. I have met with not more than a dozen specimens in a season's collecting, while *M. rosea* is very abundant in marshes. It is at times the predominant cladoceran, while *M. laticornis* has never appeared except in single specimens.

Species 28. DREPANOTHRIX DENTATA, Eurén. Plate XIII. Figs. 15–17.

1861. *Acantholeberis dentata*, Eurén, Om märkliga Crustaceer af ordningen Cladocera, funna i Dalarne. Öfvers, af K. Vet.-akad. Förh. 1861, p. 118. Description of female. Tafl. III, fig. 2. Female.

1862. *Drepanothrix sentigera*, Sars, G. O. Om de i Omegnen af Christiania jagttagne Crustacea cladocera. Forh. Vid.-Selskab. i Christiania, 1862, p. 156. Description of male and female.

1862. *Drepanothrix hamata*, Sars., Do. p. 300. Mention only.

* Daday, E. Crustacea Cladocera Faunae Hungaricæ, p. 106, Pl. II, fig. 43.

1867. *Drepanothrix hamata*, Norman and Brady. Monograph of the British Entomostraca belonging to the families Bosminidae, Macrothricidae and Lynceidae. Nat. Hist. Trans. Northumberland and Durham, 1867, p. 12, description of female. pl. XXII, figs. 5 female, 6, antennule, 7 post-abdomen.

1867. *Drepanothrix dentata*, P. E. Mueller. Danmarks Cladocera, p. 138. Description of female. Pl. II, fig. 13, antennule.

1884. *Drepanothrix dentata*, Herrick, C. L. Geol. and Nat. Hist. Survey, Minnesota. 12th Report, 1884, p. 73. Description from P. E. Mueller. Plate C, fig. 14, antennule, from P. E. Mueller. In the description of the genus the word "not" should be erased in the first sentence, "The head *not* separated from the valves by a depression."

1888. *Drepanothrix dentata*, Richard, J. Recherches sur la Faune des Eaux du Plateau Central. Clermont, 1888. Mention only.

The references given above show that this rare species occurs in Denmark, Scandinavia, Great Britain and France. I have found it here in both sexes and in considerable numbers. Sars' description is accurate, as is that of Norman and Brady. The vas deferens opens in front of the terminal claws without any prolongation of the base into a penis.

D. dentata is found in Lake Wingra at a depth of from 5–10 feet. It is most abundant in a particular zone of depth in that lake where the weeds of the marshy margin cease and those of the deeper water have not come in abundantly. Here is a stretch of bottom a few yards in width composed chiefly of broken up snail shells and vegetable debris and with a few Charae as the chief living plants. In this zone I have found this cladoceran quite common. It is not confined to it, however, but is met with both inside and outside of this limit. In the marsh proper, however, I have never found it. It is a bottom-haunting form and is therefore difficult to obtain in large numbers.

Under some conditions it is markedly repelled by light. If a portion of the bottom with this and other Cladocera is placed with water in a watch glass and the whole exposed to strong light as from a lamp, *Drepanothrix* will at once hurry to the side remote from the source of light. While *Chydorus*, *Pleuroxus*, *Daphnia* and most other forms present will congregate on the side toward the light, *Drepanothrix* hastens away from it in an awkward scramble. The sabre-like setae from which its name is derived are its chief organ of locomotion. These it uses much as a boy uses a pair of sticks to propel his sled over the ice. It can swim fairly well in the open water, but is hampered by the weight and stiffness of these setæ.

Species 29. OPHRYOXUS GRACILIS, Sars. Plate XIII. Figs. 10–12.

1862. *Ophryoxus gracilis* Sars, G. O. Oversigt af de i Omegnen af Christiania jagttagne Crustacea cladocera, p. 158. Description of male and female.

(?) 1875. *Ophryoxus paradoxurus*, Hudendorff, A. Beitrag zur Kenntniss der Süsswasser-Cladoceren Russlands, p. 43. Description of female. Tab. II., fig. 1, a. b. This species, founded on a single specimen, very possibly belongs here.

1882. *Lyncodaphnia macrothroides*, Herrick, C. L. American Naturalist, Vol. XVI, p. 1006. Description of female. Plate XVI. figs. 1, female, 2, antennae, 3, post-abdomen, 4, antennule.

1884. *Lyncodaphnia macrothroides*, Herrick, C. L. Geol. and Nat. Hist. Survey of Minnesota, 12th Annual Report, 1884, p. 74. Description of female. Pl. B, fig. 12, yg.; 13, labrum; 14, antennule; 15, last foot. Pl. B, 1, figs. 1, female; 2, post-abdomen; 3, antennule.

Ophryoxus is quite abundant in Lake Wingra, occurring through the the entire summer in openings in the marsh. It is nowhere rare, and never very plentiful. It seems to have the habit of a *Daphnia*, swimming feebly about in the open waters, rather than clinging to weeds. I give figures of the head, first leg, and the post-abdomen of the male, which have never been illustrated.

The statement that the young have a long spine, (Sars), or that the young differ in form from the adult (Herrick), need qualification. The form never differs greatly from that of the adult, and there is never any difficulty in recognizing it as the young of *Ophryoxus*. Indeed, the presence of the spine is the only important difference between the young and old. This spine is not long according to the standard of the genus *Daphnia* as it rarely measures more than $\frac{1}{4}$ of the length of the animal. It is possessed by the male as well as by the young female. In the adult female it is reduced to a sharp prominence, like that seen in many species of *Ceriodaphnia*.

Species 31. ILYOCRYPTUS LONGIREMIS, Sars. Plate XIII, fig. 18.

1888. *I. longiremis*, Sars. Additional notes on Australian Cladocera, Christ. Vid.-Selskabs Forhand. 1888, No. 7, p. 33–41. Description of male and female. Pl. iv. figs. 1, female; 2, female from below; 3, spines from edge of shell; 4, female post-abdomen; 5, male.

I am unable to distinguish our specimens from those raised by Sars out of mud from Australia. The antennary setæ, from whose length the name is derived, are even longer in our species than in Sars' figures, nearly equalling the total length of the animal. There are 5–7 superanal teeth, largest in the middle, an outer row of about eight long postanal spines and an inner row of 11–12 post-anal denticles besides several

very small teeth near the terminal claw. There are 3–4 denticles on each side of the anus. This armature of the post-abdomen distinguishes the species at once from *Ilyocryptus sordidus* and *I. acutifrons*, while the antennary setæ distinguish it from *I. agilis*. The fact that moulting is imperfect also serves to distinguish it from the latter species.

This is the common form of *Ilyocryptus* here, and is very abundant in shallow water and marshy localities throughout the summer and until after the formation of ice in the winter. The failure of food consequent on long continued cold seems the only thing which checks their multiplication. Whether *I. spinifer*, Herrick (op. cit., p. 77), is identical with this species can not be decided as none of the specific characters are mentioned or figured.

Species 37. LEYDIGIA QUADRANGULARIS, Leyd.

The shell-markings in my specimens are far more distinct than those described by European authors. Otherwise the species agrees entirely with the descriptions.

Species 40. ALONA LINEATA, Fischer.

If, following Matile's* advice, the specific name *lineata* is abandoned, my form would be *A. pulchra*, Hellich.

Species 44. ALONA LEPIDA, sp. nov. Plate XIII. Fig. 19.

Length, .8 mm.	Length of male, .6 mm.
Height, .45-50 mm.	Height of male, .3 mm.
Length post-abdomen, .40 mm.	

General shape conforms to the normal Alona type. Head depressed, rostrum sub-acute, nearly reaching the level of the ventral margin of the shell. Valves quadrangular, dorsal margin arched, superior posteal angle obtuse, well-marked. Posterior margin oblique, bearing a row of minute spinules. Inferior posteal angle rounded, very slightly emarginate. Ventral margin beset with a row of plumose setæ, of ordinary length, which ends abruptly at the posteal angle. Valves marked by close-set, conspicuous, longitudinal striæ, alternately stronger and weaker, occasionally anastomosing, running parallel to the dorsal and ventral margins and converging into a reticulated area at the anterior inferior portion of the valves. Between the striæ lie the braces.

Antennule extends nearly to end of rostrum: is spindle-shaped, largest near base, provided with an anterior sense-bristle and 6–8 subequal sense-hairs. Antennary setæ $\frac{300}{111}$. The terminal setæ are of unequal length. All are plumose and without spines. The eighth setæ is of moderate size, bi-articulate and plumose. Spines of antennae, $\frac{101}{100}$. On the middle joint of the inner branch is a circlet of small spines. Ventral margin of labrum often notched just anterior to the posterior angle,

* Matile, P. Die Cladoceren der Umgegend von Moskau, 1890, p. 46.

which is sharp. Eye moderate in size, showing four or fewer lenses. Macula nigra about as large as eye, angular, and somewhat nearer to eye than to apex of rostrum.

Post-abdomen enlarged posteriorly, lower angle rounded, bearing 15-17 serrate post-anal denticles and about the same number of squamae. Terminal claws smooth. Basal spine rather large. Abdominal setæ of ordinary length.

MALE.

Antennule cylindrical, with anterior sense-bristle and flagellum. Post-abdomen devoid of denticles and with a row of squamae. Vas deferens opens in front of terminal claw. Basal spine large.

Color yellowish to bright yellow, fairly transparent. Lake Mendota, in deeper water, 15-20 feet.

This species is evidently related to *A. elegans*, Kurz* from which it differs in its greater size, in the reticulation of part of the shell, and in the size, shape and armature of the post-abdomen. The post-abdomen of *A. lepida* resembles in general that of *A. quadrangularis*, O. F. M. The species lives at the bottom in rather deep water—15-20 or more feet—and is much more abundant in Lake Mendota than elsewhere in the vicinity of Madison.

Species 45. GRAPTOLEBERIS TESTUDINARIA, Fischer.

My species *G. inermis*,† is a variety of this species. The spine on the terminal claw is sometimes, though rarely, present, and the other characters adduced for *G. inermis* fall within the range of variation of European forms.

Species 46. DUNHEVEDIA (CREPIDOCERCUS) SETIGER, Birge. Plate XIII. Fig. 20.

In 1888, G. O. Sars‡ raised from dried mud and redescribed *Dunhevedia crassa* of King. From his description and figures it is plain that my genus *Crepidocercus* is identical with King's *Dunhevedia*, which was established in 1853. The genus was named by King from Dunheved, the place where the animal was found. My species differs from *D. crassa*, King, in the reticulation of the shell and, apparently, from *D. podagra*, King, in general form. I have not been able to see King's original paper. *D. setiger* has been found in Hungary by Daday.§

In the latter part of August I found the males of this species. *D. setiger* has always been one of the rarest species of Cladocera here. It was rarely collected at all, and if present in a dredging was found in only

* Kurz, W. Dodekas neuer Cladoceren. Sitzb. der K. Akad. der Wissensch. Wien; 1874. Separate reprint, p. 43. Description of female, Tab. II, fig. 1, female.

† Transactions Wis. Acad. Sci., vol. iv, p. 102, pl. I, fig. 17.

‡ Additional notes on Aust. Cladocera, 1888, p. 41, Pl. 5, figs. 1-4.

§ Daday, E. Crustacea Cladocera Faunæ Hungaricae, p. 98, Pl. I, fig. 47-48.

one or two specimens. At the time named I found in Lake Wingra, in water filled with *Millefolium*, immense numbers of the species in both sexes. Thousands were collected in a single haul of the cone-dredge. After about a week they disappeared and repeated efforts to find them in the same locality failed. Doubtless the winter eggs had been laid and both sexes were dead. It will be interesting to observe at what date the species will appear in 1892.

The male measures about .36 mm in length and .24 mm in height. It has the same general form as the female. The first foot has a stout hook. The post-abdomen resembles that of the female, and is provided with numerous scattered hairs. The vas deferens opens above the terminal claws. The terminal claws are smooth in both sexes, differing from *D. crassa* in which they are denticulate.

Species 47. PLEUROXUS TRIGONELLUS, O. F. Mueller.

This species is by no means abundant here, and is usually found in deep water, down to 12-15 feet.

Species 48. PLEUROXUS DENTICULATUS, Birge. Plate XIII. Fig. 21.

This is the ordinary *Pleuroxus* here. It corresponds to *P. aduncus*, Jur. in Europe. I give a figure of the male post-abdomen.

Herrick remarks on the similarity of this species to *P. procurvatus*, and suggests that the two names may really belong to varieties of the same species. I have looked carefully for connecting forms but have been unable to find then.

Species 49. PLEUROXUS GRACILIS. Hudendorff, var. UNIDENS, Birge.

I was not acquainted with Hudendorff's paper when I wrote my description of this species in 1877. Matile* notes the resemblance of the two forms and correctly points out that the chief difference lies in the overhanging projection of the upper posteal angle in *P. unidens*. As I find this difference constant and as there are other less important differences, I retain my name as characterizing a variety. Both Hudendorff and Matile note the species as rare. I did the same in my former paper, having then found only about 15 specimens. By the use of the cone-dredge I have found it quite abundant in Lake Wingra in late summer and autumn. There is no difficulty in getting 25 to 100 specimens from one haul of the dredge.

Species 60-62. CAMPTOCERCUS.

Three species of *Camptocercus* are found in Wisconsin. *C. macrurus*, O. F. M. has been formed in only a few specimens.

I am doubtful whether Schoedler's two species *C. biserratus* and *C. rectirostris* are really distinct. I find forms agreeing with both descriptions

* Die Cladoceren der Umg. von Moskau, 1890, p. 37.

in general, and include both names. In no case have I found the head directed so horizontally forward as in Schoedler's figures of *C. rectirostris.** Nor are the posteal teeth so large. Our form more nearly resembles that figured by Matile.† In the other form, the head is more depressed, the macula nigra larger than the eye, and the ventral margin of the valves is concave. I have found no specimens connecting the two forms and have therefore identified them as above.

In both species I have found individuals in which the beak was truncate, resembling that part in *C. Lilljeborgii*, Schdl., as figured by Hellich,‡ or *C. latirostris*, Kurz.§ The shell markings differ from those figured by any author. If a cast shell is examined without cover glass and not covered by water, a reticulated area is seen in the anterior part of the valves just below the middle. From this radiate most of the striæ. These are in front parallel to the anterior edge of the shell and the direction gradually changes until they are parallel to the ventral edge. Sixteen or more striæ run out on the ventral edge of the shell. The longitudinal striæ anastomose occasionally and those on the dorsal part of the valves do not bend downward into the reticulated area. I have never found specimens reticulated all over with quadrangular meshes as Hellich (l. c., pp. 76–77) figures them.

Species 63. POLYPHEMUS PEDICULUS, De Geer.

This species I have found very rarely. Only two or three specimens have been discovered at long intervals. Zacharias notes that this animal is distinctly northern in its range. My observations confirm his conclusion. I find it quite abundant in a small collection from northern Minnesota. Herrick also describes it as plentiful in Minnesota. As I have often searched vainly for it here, I believe that this locality must be close to the southern limit of its range. The same is probably true of *Holopedium gibberum*, Zad.

Species 64. LEPTODORA HYALINA, Lillj.

I quote this species by its old name, without passing on the correctness of the change to *L. Kindtii*, Focke. Focke's paper is inaccessible to me. *Leptodora* is very abundant in all our lakes. It grows to a large size and specimens 18–21 mm. in length are not rare.

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† Schoedler, J. E. Neue Beiträge zur Naturgeschichte der Cladoceren, 1853. Pl. III, fig 5.

* Matile, P. Die Cladoceren der Umgegend von Moskau. 1890. Pl. IV, fig. 26.

‡ Hellich, B. Die Cladoceren Boehmens, 1877, p. 77, fig. 37.

§ Kurz, W. Dodekas neuer Cladoceren, 1874, Pl. II, fig. 9.

‖ Zacharias, O. Die Fauna des grossen und kleinen Teiches in Riesengebirge. Zeit. Wiss. Zool. Vol. XLI., p. 492.

THE CONE-DREDGE.

The dredge which I have used for collecting seems worthy of special description. It consists of four parts: the body, the cone, the net, and the screw-top. The body is a cylinder of stout tin, strengthened by a wire at each end, four inches long, and four inches in diameter. On top of this is placed a cone of brass netting, five inches high. This is attached below to a circle of tin so that it fits into the top of the body like the cover of a tin pail. The bail of the body is of stout brass wire; the ends passed through the side of the body and enlarged, and the loop of wire shaped so as to fit within the cone and project through a hole in its top with an eye into which the dredge-line can be fastened. To the end of the line is attached a snap-hook larger than the hole in the top of the cone, so that the cone can not come off the body when in use. There are two cones provided for my dredge, one of one-tenth inch mesh, and the other of one-twentieth inch.

The $\frac{1}{10}$ inch mesh is coarse enough unless it is desired to secure very large forms. For ordinary shallow water collecting it is the best size. The cone can easily be removed for work at night in the open water.

The net is of fine cheese cloth, eighteen to twenty-two inches long, conical, large enough at the base to slip over the dredge body, to which it is tied. It is faced with stout muslin for a distance of two or three inches at each end. At the smaller end it is small enough to fit the screw-top, a tin cylinder one inch in diameter and one and one-quarter inches in length, with a wire in one end and on the other a zinc screw-top, such as are used on kerosene cans.

The seam along one side of the net is so made as to leave a sort of a loop in the cloth, through which a string can be run. One end of this string is tied about the dredge body; to the other end can be attached a weight, when desired, without having the pull of the weight come on the net.

This dredge is very useful for collecting small animals in shallow or weedy water. It can easily be thrown from the shore to a distance of 50 feet or more, thus permitting much more extensive collecting from shore than does the ordinary hand net. It can be drawn through weeds and over muddy bottoms, straining large amounts of water without becoming filled with mud or clogged with weed. If it is desired to collect from water close to the bottom without obtaining mud, a weight fastened to the end of the cord spoken of, so as to drag behind the dredge will cause the dredge to lift at each pull and so exclude most of the mud, except in very deep water. If a band of cloth is fastened about the base of the cone, leaving only the upper part free it will admit the water just above the bottom without scraping up mud. An old rake or other irregular piece of iron fastened to the dredge-line in front of the dredge will stir up the bottom and thus samples of bottom ani-

mals can be gathered from a long distance, before the dredge fills. The cone not only excludes weeds but also keeps out insects, larvæ, large Gammari, etc., which so abound in localities favorable for Cladocera, and whose size and activity made it difficult to distinguish the smaller crustacea in the collector's jar. The fact that this dredge can be pulled through weeds and strain a large quantity of water without obtaining a large amount of vegetable debris makes it very valuable in obtaining the rarer Cladocera.

The dredge is emptied by unscrewing the screw-cap and washing out the contents of the bag into a tumbler or small jar of water. In collecting near home this is brought to the laboratory for study. When it is desired to preserve collections for future study, the water is allowed to stand and settle for a short time and then the clear water containing the animals and free from mud is poured through a funnel into a small bag of cheese-cloth which is tied and put into alcohol or other preserving fluid.

With this dredge it is not at all difficult to collect 20–30 species of Cladocera from one locality and in a few hauls. In a collection thus gathered from the shore on a flying trip to some small lakelets at Manistee, Mich., I found twenty-six species of littoral Cladocera. Zacharias* in a summer's campaign in North German lakes found only twenty-three species from the shore waters.

PLATE XIII.

Fig. 1. *Latonopsis occidentalis*, Birge. Head of male, enlarged 60 diameters.
Fig. 2. " " Head of young female, enlarged 50 diameters.
Fig. 3. " " Post-abdomen of male, enlarged 75 diameters. The spines of the carapace are omitted.
Fig. 4. " " Antennule of new-hatched male, enlarged 200 diameters.
Fig. 5. " " First leg of male, enlarged 175 diameters.
Fig. 6. *Latona setifera*, O. F. M. Male antennule to show position of *appendix ciliata* (a). Enlarged 200 diameters.
Fig. 7. *Daphnia retrocurva*, Forbes. Male antennule, enlarged 200 diameters.
Fig. 8. " " Female, enlarged 30 diameters.
Fig. 9. " *hyalina*, Leyd. Male antennule, enlarged 200 diameters.
Fig. 10. *Ophryoxus gracilis*, Sars. Head of male, enlarged 65 diameters.
Fig. 11. " " Post-abdomen of male, enlarged 160 diameters.
Fig. 12. " " Part of first leg of male, enlarged 200 diameters.
Fig. 13. *Macrothrix rosea*, Jur. Antennule of male, enlarged 240 diameters.
Fig. 14. " " Post-abdomen of male, enlarged 240 diameters.
Fig. 15. *Drepanothrix dentata*, Eur. Post-abdomen of male, enlarged 175 diameters.
Fig. 16. " " Female, enlarged 65 diameters.
Fig. 17. " " First leg of male, enlarged 300 diameters.
Fig. 18. *Ilyocryptus longiremis*, Sars. Male, enlarged 100 diameters. The spines of the carapace are omitted where they would cross the post-abdomen.
Fig. 19. *Alona lepida*, Birge. Cast shell to show markings, enlarged 60 diameters.
Fig. 20. *Dunhevedia setiger*, Birge. Male, enlarged 115 diameters.
Fig. 21. *Pleuroxus denticulatus*, Birge. Post-abdomen of male, enlarged 165 diameters.

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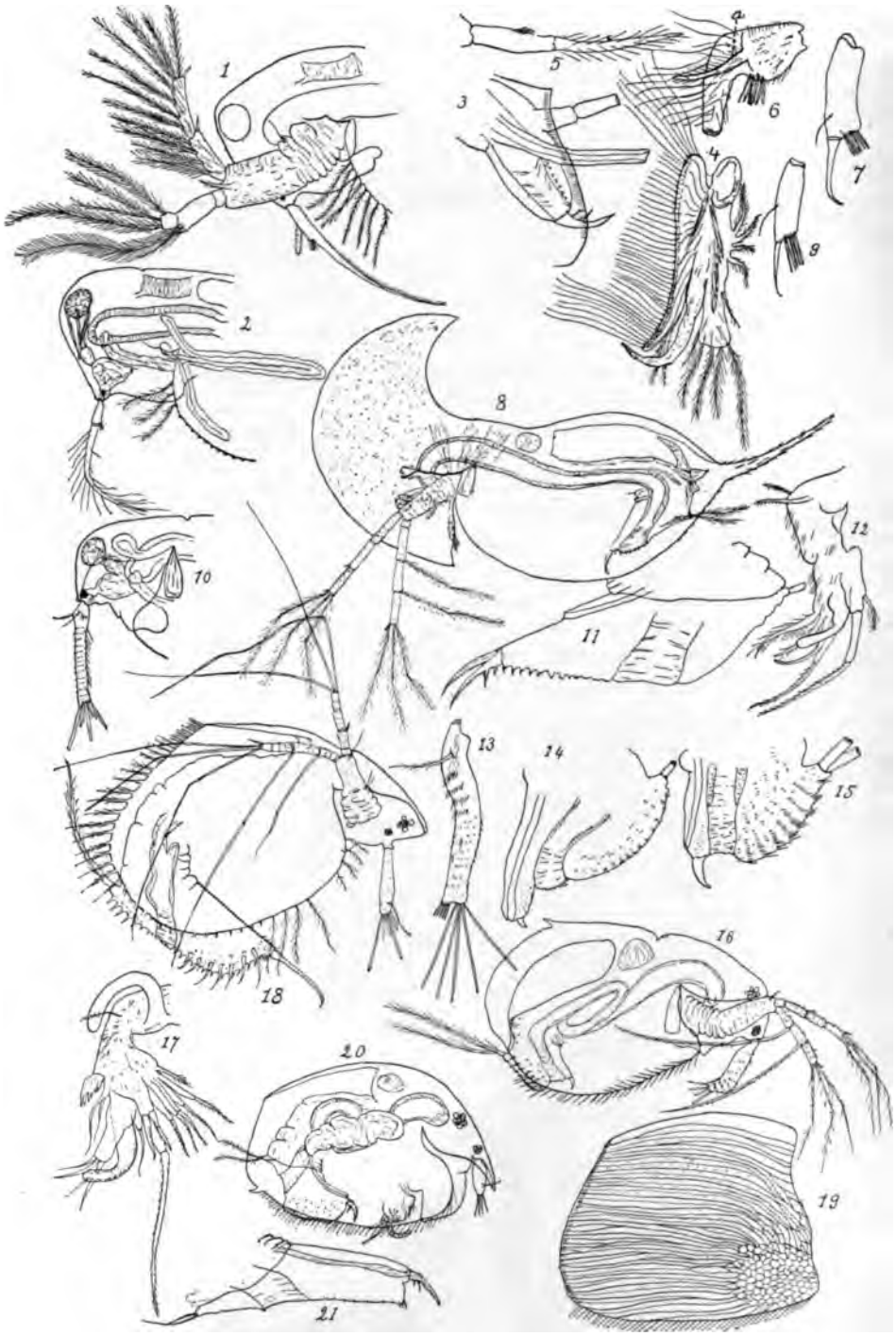
* Zacharias, O. Zur Kenntniss der pelagischen und littoralen Fauna Norddeutschen Seen. Zeit. Wiss. Zool. Vol XLV, 1887., p. 265.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NOTE ON CERUSSITE FROM ILLINOIS AND WISCONSIN.

By WM. H. HOBBS.

A few years since the University of Wisconsin obtained by purchase the mineral collections of W. T. Henry, of Mineral Point, Wis. They consist largely of the minerals associated in the zinc and lead deposits of southwestern Wisconsin and northwestern Illinois, and comprise the best series existing from that region. Among the carbonates cerussite is found, the best localities being Galena, Ill., and several points in Iowa County, Wis.

In a number of specimens in the University of Wisconsin collections the mineral is quite well crystallized and is always found on the surface of galenite, where its presence is best explained by the action of carbonated waters on the galenite. Cubes of galenite attaining in some cases dimensions of several inches are half covered by yellowish white cerussite crystals, which vary in size from a millimetre to more than a centimetre in diameter. They are stoutly columnar and translucent, with a color varying from yellowish white to light steel-gray. The faces are generally somewhat rounded, especially the terminal ones. The brachyaxis is the one of principal development, the columnar habit being given by the planes s, $\frac{1}{2}P\breve{\infty}$ (012), and u, $2P,\breve{\infty}$ (021), which have about equal development. The fundamental prism M terminates the crystals. The pyramid t, P (111) appears as a rounding of the combination edge M : s. Twins parallel to M were frequently observed. Measurements of the interfacial angles with the goniometer of the Fness *Universal-apparat* gave the following results:

	Measured	Calculated.
u : u ($2P\breve{\infty}$: $2P\breve{\infty}$)	111° 2′	110° 40′
s : s ($\frac{1}{2}P\breve{\infty}$: $\frac{1}{2}P\breve{\infty}$)	139° 54′	140° 15′
M : M ($\infty P : \infty P$)	117° 25′	117° 14′
t : t (P : P)	130°	129° 30′

The face t gave no image, the value being the average of a number of measurements by the shimmer seen when the lens was in place before the telescope.

Figure 1 shows the average development of an untwimmed individual.

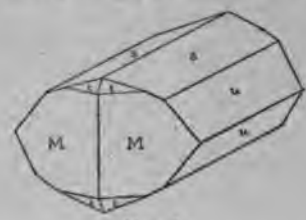

FIG. 1.

Mr. R. B. Green, late of the University of Wisconsin and now chemist for the Lake Superior Iron Company at Ishpeming, Michigan, has made an analysis of some of the more translucent crystals from Galena, Illinois, with the following results:

		Calculated for $Pb\ Co_3$.
Pb O	83.42	83.52
CO_2	16.45	16.48
	99.87	100.00

The material analyzed was specially examined for zinc with negative results.

UNIVERSITY OF WISCONSIN.

PROCEEDINGS.

PROCEEDINGS.

NINETEENTH REGULAR MEETING.

THURSDAY, December 27, 1888, 4 P. M.
COMMITTEE ROOM OF SENATE CHAMBER.

Report of treasurer and secretary read.

That of secretary approved.

The committee on nominations (Prof. Van Hise, chairman), reported the following candidates, all of whom were elected:

C. C. Pudor, Madison.
Prof. C. D. Marsh, Ripon.
Frank Leverett, U. S. G. S., Madison.
Prof. G. C. Comstock, Madison.
G. B. Ransom, U. S. Navy, Madison.
F. W. A. Woll, Madison.
Prof. Stephen M. Babcock, Madison.
Prof J. S. Brown, Madison.
Dr. H. B. Favill, Madison.
Dr. Jos. Jastow, Madison.
Prof. J. E. Olson, Madison.
Prof. W. A. Henry, Madison.
F. G. Short, chemist, Experiment Station, Madison.
Hon. G. H. Noyes, Milwaukee.
H. J. Desmond, Milwaukee.
Dr. H. A. Puls, Milwaukee.
Dr. J. M. Dodson, Milwaukee.
J. H. Dawley, Antigo.
Prof. J. Bigham, Ripon.
J. B. Thayer, Madison.

W. H. Chandler, Madison.
Prof. Storm Bull, Madison.
Rev. A. N. Somers, Ft. Atkinson.
Rev. H. D. Maxson, Menomonie.
Prof. C. S. Slichter, Madison.
Prof C. H. Chandler, Ripon.

THURSDAY, 7:30 P. M.
ASSEMBLY CHAMBER,

Joint meeting of Academy and Teachers' Association.

Paper—Importance of Libraries in Rural Schools—Hon. J. B. Thayer.

Paper—Socialism and Anarchy—Rev. H. D. Maxson.

Adjourned.

FRIDAY, Dec. 28, 9 A. M.
ROOMS OF THE ACADEMY.

Prof. Allen in the chair.

Auditing committee appointed consisting of Prof. L. M. Hoskins and Prof. Chandler.

Committee on nominations appointed consisting of Prof. Van Hise, Prof. I. M. Buell and Prof. A. J. Rogers.

The following papers were read:

"Observations on the Till Aggregations in South Eastern Wisconsin."—Prof. Ira M. Buell.

"Appendages of the First Abdominal Segment of the Embryo of the Cockroach."—W. M. Wheeler.

"Note on a Disease affecting the Head and Eyes of Fish." —Prof. E. A. Birge.

"Kame Ridges and Gravel Trains within the Area of the Green Bay Glacier."—Prof. Ira M. Buell.

"British Convicts Shipped to British American Colonies." —Prof J. D. Butler.

Adjourned.

FRIDAY, 2 P. M.
ROOMS OF THE ACADEMY.

The treasurer's report was approved on the recommendation of the auditing committee.

The following papers were read:

"Sectional Features in American Politics."—H. J. Desmond.

"The Defective Classes."—A. O. Wright.

"The Science of the English Language in the Light of the Gothic."—G. H. Balg.

"Aristotle's Physics."—Rev. J. J. Elmendorf. (This paper was read by title and a brief synopsis of it given by Prof. Allen.)

Adjourned.

FRIDAY, 7:30 P. M.
ASSEMBLY CHAMBER.

The following papers were read.

"Recent Explorations of Aztalan Mounds, with a Discussion of the Pre-historic Races of America."—Rev. A. N. Somers.

"Studies in Archaeology."—Rev. S. D. Peet.

Prof. Van Hise offered the following resolution:

That a sufficient amount of money be appropriated to illustrate the next volume of the transactions of the academy; the amount to be determined by the president, secretary and treasurer.

Carried.

Nominating committee reported the following candidates who were elected:

Dominie Schuler, 473 15th Ave., Milwaukee.

Prof. Floyd Davis, Madison.

Rev. W. A. McAtee, Madison.

Rev. J. H. Crooker, Madison.

Resolved (Prof. Van Hise), That the librarian be authorized to prepare a catalogue of the library of the academy, spending a suitable amount of money for the purpose.

Adjourned *sine die.*

TWENTIETH REGULAR MEETING.

ROOMS OF THE ACADEMY.
THURSDAY, Dec. 26, 1889.

Owing to the death of Pres. Allen, Vice-president King occupied the chair.

Moved (Prof. Barnes) that a president be elected for the unexpired term.

Carried.

Prof. Birge was elected.

President Birge in the chair.

The report of the secretary was read and approved.

Report of treasurer read.

The vice-president appointed an auditing committee consisting of Messrs. Barnes and Blackstone.

On motion, Messrs. Tatlock and H. P. Armsby were transferred to the list of corresponding members.

The president appointed Profs. Bigham and King a committee on new members.

Adjourned.

FRIDAY, 9:30 A. M.

President Birge in the chair.

Report of auditing committee was received and adopted.

The chair appointed Prof. J. D. Butler to prepare a memorial of Prof. Wm. F. Allen, Prof. T. C. Chamberlin to prepare a memorial of Prof. Roland D. Irving, and Rev. H. D. Maxson to prepare a memorial of Prof. Lucius Heritage, to be presented at the next regular meeting.

The following papers were read:

"The Chemical Constituents of Locust Bark."—F. B. Power and J. Cambier.

"Notes and a Query Concerning the Ericaceæ."—Chas. Chandler.

"Observed Discrepancies from Law of Attraction Reconciled and Certain Points of Astronomy Explained."—D. P. Blackstone.

It was moved and carried that Prof. C. O. Whitman be placed on the list of corresponding members.

The treasurer submitted a list of members many years in arrears.

Moved and carried that the names read be dropped.

Adjourned.

FRIDAY, 2:30 P. M.

Mr. A. J. Rogers in the chair.

The following papers were read:

"Kentucky Pioneers."—James D. Butler.

"Problems of Hypnotism."—Joseph Jastrow.

"On some Metamorphosed Eruptives in the Crystalline Rocks of Maryland."—Wm. H. Hobbs.

Adjourned.

FRIDAY, 8 P. M.

President Birge in the chair.

The committee on nominations reported the following names for membership.

Mr. Caleb N. Harrison, Milwaukee.

Prof. N. S. Fuller, Ripon.

Prof. A. A. Upham, State Normal School, Whitewater.

Prof. Chas. E. Bennett, Madison.

Dr. Wm. H. Hobbs, Madison.

Prof. C. P. Sennott, State Normal School, Milwaukee.

The Secretary was directed to cast the vote of the Academy for these persons.

The following papers were read:

"Science as Related to Invention."— A. J. Rogers.

"Some new Theories of the Greek perfect in Ka." — Chas. E. Bennett.

Moved and carried that the council be authorized to expend the amount necessary to meet the running expenses of the year.

Adjourned *sine die.*

GEO. W. PECKHAM,
Secretary.

TWENTY-FIRST REGULAR MEETING.

ROOMS OF THE ACADEMY,
TUESDAY, Dec. 30, 1890, 9 A. M.

President Birge in the chair.

Report of secretary read and approved.

In the absence of the treasurer, Hon. S. D. Hastings, Mr. F. W. McNair presented his report.

The president appointed Messrs. Van Hise and Barnes auditing committee on treasurer's report.

F. M. McNair read a list of members and the amounts due from each to date.

The following program was then followed:

"Recent Progress in the Chemistry of Sugars."—H. W. Hillyer.

"Some Observations on Lake Superior Stratigraphy."—C. R. Van Hise.

"Electro-Deposition of Aluminum in Aqueous Solutions."—A. J. Rogers.

"On Cleavage and Lamination in Gneisses and their Relation to Bedding."—Wm. H. Hobbs.

"The Eleventh Amendment to the Constitution."—C. H. Haskins. (Read by Prof. F. J. Turner.)

Adjourned.

TUESDAY, 2:30 P. M.

The auditing committee reported that the treasurer's report and vouchers had been examined and found to be correct. Signed C. R. Van Hise and C. R. Barnes.

On motion of Prof. Jastrow the report was approved.

The president appointed Pres. Chamberlin and Peckham a committee on new members.

The regular program was then resumed.

"Recent Theories of the Evolution of Sex." — Somers.

"Some Generalizations of Comparative Psycholog Jos. Jastrow.

"Glacial Lobation in Ohio." — Frank Leverett.

"Recent Progress in Correlation and Differentiat Glacial Deposits." — T. C. Chamberlin.

"Hypnotism." — A. N. Somers.

The committee on new members reported the foll nominations:

Dr. C. H. Haskins, Madison.

Prof. E. S. Goff, Madison.

Prof. C. D. Marx, Madison.

Prof. A. A. Knowlton, Madison.

Prof. W. S. Leavenworth, Ripon.

On motion the secretary was instructed to cast the of the Academy for these new members.

The meeting then adjourned.

TUESDAY, 7:30 P.

The academy listened to the address of Pres. E. A. on "Recent Problems in Biology."

On the President's suggestion the usual formalities waived and a very general discussion ensued.

The committee on nomination of officers reported a lows:

President, Prof. Geo. W. Peckham, Milwaukee.

Vice-president for Science, Prof. R. D. Salisbury, B vice-president for Letters, Rev. H. D. Maxson, Menom vice-president of Arts, Prof. F. B. Power, Madison.

Treasurer, Hon. S. D. Hastings, Madison.

Secretary, Prof. C. E. Bennett, Madison.

Curator and librarian, Prof. Wm. H. Hobbs, Madiso

On motion the secretary was directed to cast the ballot of the Academy for the new officers.

It was moved and carried that the council be authorized to expend the amount of money necessary to meet the expenses of the ensuing year.

Adjourned *sine die.*

C. E. BENNETT,
Secretary.

NOTE — In June, 1891, the secretary, Prof. C. E. Bennett removed to Providence, R. I., and in September the president appointed Prof. Wm. H. Hobbs the secretary, *ad interim.*

TWENTY-SECOND REGULAR MEETING.

ROOMS OF THE ACADEMY.
TUESDAY, DEC. 29th,

Meeting called to order at 9:30 A. M.

Vice-president F. B. Power in the chair.

The report of the secretary was read and accepte

The treasurer, Hon. S. D. Hastings, then read his

It was moved and carried that the following men made honorary members of the Academy:

Prof. C. E. Bennett, Providence, R. I.

Mr. Ira M. Buell, Sun Prairie, Wis.

Prof. J. W. Stump, Oswego, N. Y.

Prof. C. D. Marx, Palo Alto, Cal.

The treasurer was given authority to drop from of members all who were in arrears more than thre

The presiding officer appointed Prof. C. D. Mar Frank Leverett and Rev. A. N. Somers, a comm audit the treasurer's report.

The report of the librarian and custodian was ne

The librarian reported that the books of the libra been re-arranged and a card catalogue begun. He mended to the Academy the appointment of a libra mittee of three, including the librarian, to consider of enlarging the library and making it more acces members. It was further recommended that this c tee be authorized to purchase from the funds Academy such odd volumes as may be necessary plete the series of important journals.

It was moved by Prof. Van Hise to amend by ing the expenditures of the committee to be subject approval of the council. Carried.

The recommendation was then adopted, and the presiding officer appointed Prof. G. L. Hendrickson and Prof. Geo. C. Comstock and the librarian, the library committee.

The custodian recommended that the collection of fossils belonging to the Academy be deposited in the collection of the University of Wisconsin to be stored by itself and labeled as the property of the Wisconsin Academy.

Prof. Birge moved that the recommendation be adopted subject to the acceptance of the university authorities.

Carried.

Prof. J. W. Stearns, in a brief address, reviewed the life of Rev. H. D. Maxson, the late vice-president of the Department of Letters, and paid a tribute to his many sterling qualities, to which Profs. Van Hise and Marsh added their testimony.

The president asked Prof. Stearns in the name of the Academy, to prepare a memorial of the life of Rev. Mr. Maxson for publication in the Transactions.

The president then appointed the following committees:

On Nominations of Officers — Profs. Van Hise, Birge and Hillyer.

On New Members — Profs. Birge, F. H. King and Turner.

On Publication — The Secretary *ex-officio* and Profs. Van Hise, Loomis and H. C. Tolman.

The literary program was then begun:

"Origin of the Iron Ores of the Lake Superior Region."— C. R. Van Hise, 25 minutes.

Discussed by Mr. Sennott.

"On New Attidae."— G. W. Peckham. (Read by title.)

"Notes on a Little Known Region of Northwestern Montana."— G. E. Culver, 25 minutes.

Discussed by Dr. Butler, Prof. Van Hise and Mr. Leverett.

"Some Influences of Sex on Personality."— A. N. Somers. (Read by title.)

"On the Limonene Group of Terpenes."— Edward Kremers. (Read by title.)

The meeting then adjourned till afternoon.

AFTERNOON SESSION, 2:30 P. M.

The auditing committee, through its chairman, Prof Marsh, announced that the report and vouchers of th treasurer had been examined and found to be correct.

The program was then resumed.

"Notes on the Depth and Temperature of Green Lake. —C. Dwight Marsh.

"On the Deep Water Crustacea of Green Lake."—C Dwight Marsh, 15 minutes.

Discussed by Profs. Birge and Van Hise.

"The Present Condition of the Latitude Problem."—G. C Comstock, 30 minutes.

Discussion by Profs. Butler, Davies, Hoskins, Loomi and Van Hise.

"On Certain Analogies between the Theories of Elasticit and Electro magnetism."—J. E. Davies, 25 minutes.

"On the Authenticity of the Commentariolum Petitioni of Quintus Cicero."—G. L. Hendrickson, 20 minutes.

"The effect of Changes of Temperature on the Distribu tion of Magnetism."—H. B. Loomis, 25 minutes.

The Academy adjourned till evening.

EVENING SESSION. 7:30 P. M.

The committee on New Members, through its chairman Dr. Birge, nominated the following for membership, an the secretaty was instructed to cast the ballot of the Acad emy for them.

Prof. G. A. Tolbert, Racine.
Mr. Geo. E. Luther, U. S. G. S., Madison.
Prof. F. L. Van Cleef, Madison.
Prof. G. L. Hendrickson, Madison.
Dr. H. B. Loomis, Madison.
Prof. G. E. Culver, Madison.
Dr. A. H. Tolman, Ripon.
Mr. S. D. Townley, Madison.
Dr. Edward Kremers, Madison.

Dr. H. C. Tolman, Madison.
Dr. C. F. Hodge, Madison.
Prof. W. A. Eckels, Ripon.

The literary program was then resumed.

"On Some Interesting Pseudomorphs from the Taconic Region."— Wm. H. Hobbs, 10 minutes.

"On Cladocera of Madison, Wisconsin."— E. A. Birge, 30 minutes.

Discussion by Profs. Jastrow, Barnes and Marsh.

"Some New Points in the Physiology and Hygiene of Nerve Fatigue."— C. F. Hodge, 30 minutes.

Discussion by Prof. Jastrow.

"On the Correlation of Moraines and Raised Beaches of Lake Erie."— Frank Leverett, 30 minutes.

Meeting adjourned till next day.

WEDNESDAY, 9 A. M.

"The Council Houses and Clan Centres of the Effigy Builders."—Dr. S. D. Peet, 25 minutes. (Read by his son, Mr. C. E. Peet.)

Prof. Leverett then supplemented his paper of Tuesday evening which had been abridged owing to the lateness of the hour.

"On Two New Occurrences of Diabase."—G. E. Culver and Wm. H. Hobbs, 20 minutes.

"The Pseudo-Gregorian Drama *Χρίστος Πάσχων* in its Relation to the Text of Euripides."—F. L. Van Cleef. (Read by title.)

"Early Lutheran Immigration to Wisconsin."—Kate A. Everest, 15 minutes. (Read by F. J. Turner.)

The Committee on Nomination of Officers through its chairman, Prof. Van Hise, nominated for vice-president of the Department of Letters, vice Rev. H. D. Maxson, deceased, Dr. A. H. Tolman of Ripon, and for secretary, vice Prof. C. E. Bennett removed to Providence, R. I., Dr. Wm. H. Hobbs of Madison.

The secretary was instructed to cast the ballot of the academy for these officers.

The program was then resumed.

"Clocks and Watches"—R. G. Norton, 8 minutes.

"Ponderable and Imponderable Fluids."—Simeon Mills, 10 minutes.

"Limited Distribution of the Waterloo Boulder Train."—Ira M. Buell.

Prof. Van Hise spoke of the desirability of holding a local meeting each year, at some of the educational centres of the state, in addition to the regular annual meeting held in Madison, and moved that the council be authorized to hold such a meeting before the next annual meeting making all necessary arrangements as to time and place. After discussion by the president, Prof. Marsh and others, the measure was carried unanimously.

On motion of the treasurer, Dr. A. L. Chapin of Beloit, was made a life member of the academy.

The meeting then adjourned *sine die.*

WM. H. HOBBS,
Secretary.

REPORTS OF TREASURER.

MADISON, December 27, 1888.

To the Wisconsin Academy of Sciences, Arts and Letters.

GENTLEMEN: The undersigned would respectfully present the following statement of the financial transaction of the Academy during the past year:—

Balance on hand December 27, 1887	$849 19	
Received from members during the year for fees and dues	53 00	
Received from interest on permanent loan	40 00	
		$942 19

The disbursements have been as follows:—

1888.			
Jan. 21.	Paid Nelson & North for printing blank notices	$2 00	
June 4.	Paid Luding Kumlein for redrawing maps	10 00	
July 2.	Paid Moss Engraving Co. engraving plates	50 00	
Oct. 2.	Paid Marr & Richards, engraving maps	10 00	
Dec. 1.	Paid M. J. Cantwell for printing	7 75	79 75
	Balance on hand, Dec. 27, 1888		$862 44

Vouchers herewith submitted,

SAMUEL D. HASTINGS.
Treasurer.

To the Wisconsin Academy of Sciences, Arts and Letters:

GENTLEMEN: The following is a statement of the financial transactions of the Academy during the past year, viz.:

Balance on hand as per last statement	$862 44
Received for interest on, permanent fund	40 00
Received from members for initiation fees and annual dues	85 50
	$987 94

The disbursements on the order of the president and secretary have been as follows, viz.:

1879.			
Jan. 10.	Paid W. F. Allen on account of catalogues.....	$10 00	
Jan. 17.	Paid W. F. Allen on account of catalogues.....	12 40	
Jan. 18.	Paid Burdick, Armitage & Allen for printing	8 50	
Jan. 18.	Paid G. W. Peckham for postage and envelopes	2 65	
Mar.	Paid E. A. Birge for cash paid for catalogueing library.....	16 00	$49 55
	Balance on hand Dec. 26, 1889.....		$938.39

Respectfully submitted,

SAMUEL D. HASTINGS,

Treasurer.

Vouchers herewith submitted.

MADISON, December 30, 1890.

To the Wisconsin Academy of Sciences, Arts and Letters:

GENTLEMEN: The following is a statement of the financial transactions of the Academy during the past year, viz.:

Balance on hand as per last statement.....	$938 39	
Received for interest on permanent fund.....	40 00	
Received from members for initiation fees and annual dues.....	88 00	
		$1,066 39

The disbursements on the order of the president and secretary have been as follows, viz.:

1889.			
Dec. 27.	Paid S. D. Hastings for postage and envelopes for 6 years.....	$15 50	
	Paid Geo. W. Peckham, postage, envelopes, etc .	1 68	
Dec. 28.	Paid Burdick, Armitage & Allen, for printing....	6 75	
1890.			
Feb. 3.	Paid E. A. Birge for postage, etc.....	27 00	
Feb. 18.	Paid Am. Express Co.....	6 75	
Mar. 7.	Paid Adams Express Co.....	3 95	
	Paid C. E. Hoyt for putting up documents.....	5 00	
Nov. 4.	Paid G. W. Peckham for bills of Moss Engraving Co., N. Y.....	30 10	
			$96 73
	Balance on hand Dec. 30, 1890.....		$969 66

Respectfully submitted,

SAMUEL D. HASTINGS,

Treasurer.

MADISON, December, 1891.

To the Wisconsin Academy of Sciences, Arts and Letters:

GENTLEMEN: The following is a statement of the financial transactions of the Academy during the past year:—viz.:

Balance on hand as per last statement	$969 66
Received for interest on permanent loan	40 00
Received from members for initation fees and annual dues	59 00
Total	$1,068 66

The disbursements upon the order of the president and secretary have been as follows, viz.:

1890.			
Oct. 30.	Paid L. S. Cheney for cataloging books, etc.	$16 20	
1891.			
Jan. 31.	Paid A. C. McClurg & Co., printing, etc.	4 35	
Feb. 21.	Paid Chas. E. Bennett, postage and express	1 75	
Mar. 4.	Paid Mrs. E. A. Birge, for express	1 00	
May 4.	Paid Burdick, Armitage & Allen for printing	3 50	
Aug. 6.	Paid State Journal, printing, etc.	2 85	
Nov. 11.	Paid Detrich & Adams stamp pad, etc.	75	
Nov. 11.	Paid Library Bureau (Boston), sundries	12 88	
Nov. 11.	Paid W. H. Hobbs, postage, express, etc.	7 90	
Total			$51 15
Balance on hand — 1891			$1,017 51

Respectfully submitted,

SAMUEL D. HASTINGS,
Treasurer.

REPORT OF THE LIBARIAN AND CUSTODIAN.

(*Presented at the Twenty-second Regular Meeting, December 29th*, 1891.)

The arrangement and cataloguing of the books of the library has been begun during the past year, and the catalogue is about a third completed. The work has been much hindered because access to the rooms can be had only on Saturdays and during vacations, owing to their being used for meetings of the law and history classes. The cases and shelves have been washed and the doors fitted with new locks where necessary. The cases have been given numbers from 1 to 31, and the shelves letters. The dust of ages has been removed from the books and a temporary arrangement made on the plan which follows.

As most members know, the library consists almost solely of journals obtained in exchange for the Transactions of the Academy. A primary classification has been made into: (1) Journals which treat of Sciences, Arts and Letters. (2) Journals restricted to Sciences. (3) Journals treating of special sciences, as biological journals, geological journals, etc. (This class contains a subdivision for each science or group of sciences represented.) (4) Journals relating solely to the Arts. (5) Journals relating to Letters. Supplementary to each of these divisions is a small collection of separate works and brochures of papers in other journals. The bulk of the library of the Academy is embraced in the first three divisions — general and scientific journals.

Under this primary grouping the journals are classified according to language, as English, German, French, Italian, Dutch, Norwegian, Swedish, Russian, etc.

A list showing this arrangement, with the number of cases

where the journals of each department are to be found, will be posted this noon near the door, so that members can inspect the shelves and learn what journals the library possesses in each or any department of knowledge.

The card catalogue has been adopted as in every way the most convenient and the best adapted to any change of arrangement of books that may in future become necessary. (I should perhaps state that a partial card catalogue exists, but as it does not tell where the books are to be found, it proved easier to make a new one than to use the old one.) The present classification of the cards is the same as that of the books, and each card gives reference to number of case and letter of shelf where the book is to be fonnd. The books have been given numbers on the following plan: Each journal has a journal number, and each volume of that journal a volume number separated from the journal number by a space and period. The volume number is generally the number of the volume. This makes it convenient to number and catalogue accessions.

It is proposed, if possible, to finish the catalogue before spring and publish a list of the journals in volume viii of the Transactions.

The acknowledgment of books received and the details of the work of cataloguing have been carried out by Mr. L. S. Cheney, Fellow in Biology of the University of Wisconsin, who has been paid for the work. Credit is due him for the care he has exercised in a work requiring considerable care. Journals have in some cases been found bound with incorrect titles, parts of a volume bound with odd numbers left out, etc.

At the next annual meeting of the Academy I expect to be able to present a list of the most valuable of the journals, and the Academy will be asked to appropriate money for binding them.

As soon as the library is catalogued it will, I think, possess considerable value to many of the members as a library of reference. It includes many quite important journals. I would recommend to the Academy the appointment of a library committee of three, of whom the librarian shall be

a member *ex-officio*, to consider means of increasing our list of exchanges, other means of enlarging and improving the library, and how it shall be made most accessible to members. The constitution provides that such a committee be appointed annually. I recommend that this committee be given authority to purchase—subject to the approval of the council—from the funds of the Academy odd volumes, when necessary to complete our series.

As custodian of the collection of specimens of the Academy, I have little to report. The value of the collection consists mainly in the type fossils of the late Wisconsin Geological Survey, whose space on the shelves is needed for the library. I recommend that these fossils be deposited in the collections of the University of Wisconsin where they can be stored by themselves, labelled as the property of the Wisconsin Academy, and be accessible for study. This would be done subject to the approval of the university authorities.*

Respectfully submitted,

WM. H. HOBBS,

Librarian and Custodian.

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* The recommendations in this report were favorably acted on by the Academy. (See proceedings, p. 412.) The work of the library committee is hardly more than begun, and a full report will be given at the next annual meeting. The action of the Academy on the second recommendation (concerning collection of fossils), has been presented to the faculty of the University of Wisconsin, and on their recommendation permission was given by the Board of Regents to transfer the collection to the university. The transfer has been made accordingly.—SECRETARY, April, 1892.

OFFICERS AND MEMBERS

OF THE

WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS, 1892.

OFFICERS.

PRESIDENT,
PROF. GEO. W. PECKHAM,
Superintendent of Schools, Milwaukee.

VICE-PRESIDENT OF SCIENCES,
PROF. ROLLIN D. SALISBURY,
University of Wisconsin, Madison.

VICE-PRESIDENT OF ARTS,
PROF. F. B. POWER,
University of Wisconsin, Madison.

VICE-PRESIDENT OF LETTERS,
PROF. A. H. TOLMAN,
Ripon College, Ripon.

SECRETARY,
PROF. WM. H. HOBBS,
University of Wisconsin, Madison.

TREASURER,
HON. S. D. HASTINGS, Madison.

LIBRARIAN AND CURATOR,
PROF. WM. H. HOBBS, Madison.

COMMITTEE ON PUBLICATION.

THE SECRETARY, *ex-officio.*

PROF. C. R. VAN HISE, Madison.
PROF. H. B. LOOMIS, Madison.
PROF. H. C. TOLMAN, Madison.

COMMITTEE ON LIBRARY.

THE LIBRARIAN, *ex-officio.*

PROF. GEO. L. HENDRICKSON, Madison.
PROF. GEO. C. COMSTOCK, Madison.

LIFE MEMBERS.

Prof. Edward A. Birge, Madison.
Dr. A. L. Chapin, Beloit.
Prof. J. E. Davies, Madison.
Gen. G. P. Delaplaine, Madison.
Hon. J. L. Hill, Chicago, Ill.
Hon. John W. Hoyt, Cheyenne, Wyoming.
Hon. John L. Mitchell, Milwaukee.
Hon. J. G. Thorp, Eau Claire.

CORRESPONDING MEMBERS.

Abbott, C. C., M. D., Trenton, N. J.
Andrews, Edmund, A. M., M. D., Prof. Chicago Medical College, Chicago, Ill.
Armsby, Prof. H. P., State College, Pa.

Barron, John W., 113 E. 17th St., New York, N. Y.
Bennett, Prof. C. E., Brown University, Providence, R. I.
Benton, J. G., M. D., Philadelphia, Pa.
Bridge, Norman, M. D., Chicago, Ill.
Buchanan, Joseph, M. D., Louisville, Ky.
Byrness, R. M., M. E., Cincinnati, Ohio.

Caverno, Rev. Charles, Lombard, Ill.
Crooker, Rev. J. H., Helena, Montana.

Davis, Floyd, Des Moines, Iowa.

Ebenzer, F., Ph. D., Baltimore, Md.

Fallows, Right Rev. Bishop Samuel, Chicago, Ill.
Fiske, E. O., Minneapolis, Minn.

Gilman, D. C., Ph. D., LL. D., President Johns Hopkins University, Baltimore, Md.

Harris, W. T., LL. D., Concord, Mass.
Higley, W. K., Chicago, Ill.
Holden, Prof. E. S., Director Lick Observatory, San José, Cal.
Holland, Rev. F. M., Concord, Mass.
Hopkins, F. N., M. D., Baton Rouge, La.
Horr, M. D., President Iowa Inst. Arts and Sciences, Dubuque, Iowa.
Hubbell, H. P., Winona, Minn.

Jewell, J. S., A. M., M. D., Prof. Chicago Medical College, Chicago, Ill.

Le Barron, Wm., State Entomologist, Geneva, N. Y.

Marcy, Oliver, LL. D., Prof. Northwestern University, Evanston, Ill.
Marx, Prof. C. D., Stamford University, Palo Alto, Cal.
Morgan, L. H., LL. D., Rochester, Ill.

Newberry, Prof. J. S., LL. D., Prof. Columbia College, New York, N. Y.

Orton, Prof. E., A. M., President State University, and State Geologist, Columbus, Ohio.

Paine, Alford, S. T. D., Hinsdale, Ill.
Peet, Rev. Stephen D., Ph. D., Avon, Ill.
Potter, Prof. W. B., Washington University, St. Louis, Mo.

Safford, Prof. T. H., Williams College, Williamstown, Mass.
Sawyer, Prof. W. C., ————.
Shaler, Prof. N. S., A. M., Harvard University, Cambridge, Mass.
Shipman, Col. S. V., Chicago, Ill.

Somers, Rev. A. N., La Porte, Ind.
Steele, Rev. G. M., Principal Wilbraham Seminary, Wilbrah
Mass.
Stump, Prof. J. W., Oswego, N. Y.

Tatlock, John, Jr., ————.
Trelease, Prof. William, Washington University, St. Louis, Mo.
Trumbull, J. H., LL. D., Hartford, Ct.

Van de Warker, Eli, M. D., Syracuse, N. Y.
de Vere, Prof. Schele M., LL. D., University of Virginia, Va.
Verrill, Prof. A. E., A. M., Yale University, New Haven, Ct.

Whitman, Prof. C. O., Clark University, Worcester, Mass.
Whitney, Prof. W. D., Yale University, New Haven, Ct.
Winchell, Prof. N. H., State Geologist, Minneapolis, Minn.

Young, Rev. A. A., Monona, Iowa.

NOTE.—The above list is believed to contain many errors. Note of corrections shoul
sent to the secretary.

ACTIVE MEMBERS.

Barnes, Prof. C. R., Madison.
Balg, Prof. G. H., Mayville.
Bartlett, Dr. E. W., Milwaukee.
Beach, Prof. W. H., Milwaukee.
Beaty, Hon. Henry, Milwaukee.
Blackstone, Prof. D. P., Berlin.
Blaisdell, Prof. J. J., Beloit.
Buel, Ira M., Sun Prairie.
Butler, Prof. J. D., Madison.
Bull, Prof. Storm, Madison.

Carr, Chas. F., Madison.
Chamberlin, President T. C., Madison.

Chandler, Prof. C. H., Ripon.
Chandler, Hon. W. H., Madison.
Comstock, Prof. Geo. C., Madison.
Conover, Mrs. Sarah F., Madison.
Culver, Prof. G. E., Beloit.

Daniells, Prof. W. W., Madison.
Dawley, Prof. J. H., Antigo.
Desmond, Hon. H. J., Milwaukee.
Doyle, Hon. Peter, Milwaukee.

Emerson, Prof. Joseph, Beloit.
Eckels, Prof. W. A., Ripon.

Foye, Prof. J. C., Appleton.
Frankenburger, Prof. D. B., Madison.

Greene, Thos. A., Milwaukee.
Gordon, Mrs. Geo., Milwaukee.

Harrison, Caleb H., Milwaukee.
Haskins, Prof. C. H., Madison.
Hastings, Hon. S. D., Madison.
Hendrickson, Prof. G. L., Madison.
Henry, Prof. W. A., Madison.
Hillyer, Prof. H. W., Madison.
Hobbs, Prof. Wm. H., Madison.
Hodge, Prof. C. F., Madison.
Hoskins, Prof. L. M., Madison.
Hoy, Dr. P. R., Racine.

Jastrow, Prof. Joseph, Madison.

Kerr, Prof. Alexander, Madison.
King, Prof. F. H., Madison.
Knowlton, Prof. A. A., Madison.
Kremers, Prof. Edward, Madison.

Lamb, F. J., Madison.
Leverett, Frank, (U. S. Geol. Survey), Madison.
Leavenworth, Prof. W. S., Ripon.

Luther, Geo. E. (U. S. Geol. Survey), Madison.
Loomis, Prof. H. B., Madison.

Marks, Dr. Solon, Milwaukee.
Marsh, Prof. C. Dwight, Ripon.
Meacham, Dr. J. G., Sr., Racine.
Meacham, Dr. J. G., Jr., Racine.
Mills, Hon. Simeon, Madison.
McLangen, Chas., Milwaukee.
Morris, W. A. P., Madison.

Nader, Capt. John, Madison.
Norton, R. G., Madison.
Noyes, Hon. G. H., Milwaukee.

Orton, Hon. H. S., Madison.

Parkinson, Prof. J. B., Madison.
Peckham, Prof. Geo. W., Milwaukee.
Power, Prof. F. B., Madison.
Pray, Prof. T. B., Whitewater.
Puls, A. J., Milwaukee.
Pudor, Prof. C. C., Madison.

Rogers, Prof. A. J., Milwaukee.

Salisbury, Prof. R. D., Madison.
Schuler, Dominee, Milwaukee.
Sennott, Chas. P., Milwaukee.
Schneiding, Henry E., Racine.
Smith, Prof. E. G., Beloit.
Sprague, A. R., Milwaukee.

Thayer, Hon. J. B., Superior.
Thwaites, Prof. R. G., Madison.
Turner, Prof. F. J., Madison.
Tolman, Prof. A. H., Ripon.
Tolman, Prof. H. C., Madison.
Townley, S. D., Madison.
Tolbert, Prof. G. A., Racine.

Upham, Arthur A., Whitewater.

Van Cleef, Prof. F. L., Madison.
Van Hise, Prof. C. R., Madison.
Van Velzer, Prof. C. A., Madison.
Viebahn, Prof. C. F., Watertown.

Wheeler, Prof. W. M., Milwaukee.
Wright, Prof. A. O., Madison.

NOTE.—Members will accommodate the secretary by promptly informing him of any errors or omissions in the above list.

DECEASED MEMBERS.

Allen, W. C.
Allen, Prof. Wm. F., Prof. of History, University of Wisconsin.
Armitage, W. E., Right Rev. Bishop, P. E. Church, Milwaukee.

Carpenter, S. H., LL. D., Prof. of English Language, University of Wisconsin.
Case, J. I., Racine.
Conover, O. M., LL. D., Madison.

De Koven, S. T. D., Warden Racine College, Racine.
Dewey, Nelson.
Draper, L. C.
Dudley, Wm., Madison.

Eaton, J. H., Ph. D., Prof. of Chemistry, Beloit College.
Engelman, Peter, Director German and English Academy, Milwaukee.

Feuling, J. B., Ph. D., Prof. Philology, University of Wisconsin.

Hawley, C. T., Milwaukee.
Heritage, Lucius, Prof. of Latin, University of Wisconsin.
Holton, Hon. E. D., Milwaukee.

Irving, R. D., E. M., Ph. D., Prof. of Geology, University of Wisconsin, and U. S. Geologist.

Knapp, Hon. J. G., Milwaukee.
Kumlein, Thure.

Lapham, I. A., LL. D., State Geologist, Milwaukee.
Lawler, Hon. John.
Lewis, Mrs. H. M.
Little, Thomas H., Supt. Institution for the Blind, Janesville.

McDill, A. S., M. D., Supt. State Hospital for the Insane, Madison.

Nicodemus, W. J. L., A. M., C. E., Prof. of Engineering, University of Wisconsin.

Paul, Hon. Geo. H., Milwaukee.
Pradt, J. B.

Reed, George.

Smith, Wm.

Winchell, Prof. Alexander, University of Michigan, Ann Arbor, Mich.

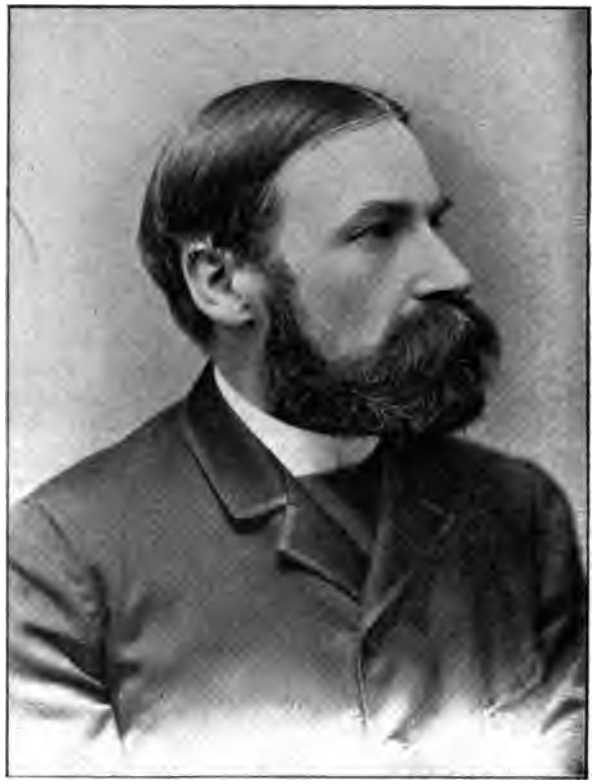
In Memoriam.

Roland Duer Irving.

William Francis Allen.

Lucius Heritage.

Henry Doty Maxson.



[Courtesy of American Geologist.]

Roland D. Irving

ROLAND DUER IRVING.

Former President of the Wisconsin Academy of Sciences, Arts and Letters.

By T. C. CHAMBERLIN,*

President of the University of Wisconsin.

Professor Irving was born in the city of New York, on the 29th day of April, 1847. His father, the Rev. Pierre P. Irving, was a clergyman of the Episcopal church and a nephew of Washington Irving. His mother was a daughter of Chief Justice John Duer, of the supreme court of New York. Sprung thus from a family of literary talent on the one side and of judicial on the other, Professor Irving inherited tastes and capabilities that especially fitted him for his subsequent work. His birth and early education in the metropolis of our country impressed upon him something of the breadth and complexity of its commercial, social and intellectual activities and gave to a mind naturally disposed to large and analytic conceptions a pronounced breadth and a discriminative habit. His youth was spent upon Staten Island, to which his father had removed in his second year. A lack of entire robustness of health, emphasized by frequent attacks of illness and a weakness of sight, interfered with systematic study and checked the indulgence of his passionate fondness of reading. His early training was therefore conducted mainly at home, his father and sisters being his chief instructors. It was only in his twelfth year that he entered school. His dominant studies were classical, but he was fortunate in falling under the instruction of a teacher whose frequent rambles with his pupils fostered a love for natural history. Young Roland became especially interested in the collection of the rocks and minerals that were accessible upon the island. The identification and classification of these may be looked upon as the initiation of his subsequent scientific studies. In 1863 he entered the classical course of Columbia college. Forced by the condition of his eyes to suspend his studies in his sophomore year, he spent six months in England, the impress of which in certain choices of language and methods of thought remained with him throughout

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* This Sketch was first published in the American Geologist for January, 1887.

his life. On his return he was able to resume studies, though it was necessary that the greater part of the texts should be read to him. This probably strengthened a memory naturally retentive and drove him to meditative and independent thought, since he was measurably cut off from indulgence in simple acquisition. A full course in the School of Mines, of Columbia College, gave him the technical foundation for his future work.

During two of his summer vacations he found employment and practical experience in the coal mines of Wiconisco, Penn. Soon after graduation he was appointed superintendent of the smelting works at Greenville, N. J. Following this he was employed during parts of two years upon the Ohio geological survey. His career thus far had lain chiefly in the line of technical work. From this he was turned aside in 1870 by a call to the department of geology, mineralogy and metallurgy in the University of Wisconsin, and from that time onward his activities took two parallel lines, instruction and investigation. As an instructor his work was characterized by thoroughness, by a masterly command of the subjects he taught, by clearness of presentation and a graphic and humorous exposition, by perfect candor and sincerity, by earnestness, devotion and indefatigable industry—a rare combination of qualities, which made him not only a singularly effective instructor, but a worthy leader in all those moral and manly influences which characterize the true teacher.

Professor Irving's first independent geological investigation consisted of the demonstration that the Baraboo quartzites of central Wisconsin are very much older than the adjacent upper Cambrian sandstone (Dikelocephalus horizon), which was at the time a battled question.* Shortly after he made similar investigations on the quartzites near Waterloo, Dodge Co., Wis.†

Upon the inauguration of the recent geological survey of Wisconsin (1873), Professor Irving was appointed one of the three commissioned assistant geologists and began his well-known investigations in that connection. During the first year he was assigned to the study of the Penokee iron range. He was here compelled, at the outset of his official career, to encounter unwarranted expectations raised by previous flattering opinions respecting the richness of the iron deposits given by incautious and inexpert explorers. His perfectly candid and unreserved report brought the usual reward of frankness and sincerity in the face of opposing desire, at first a storm of protest and of adverse

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*On the Age of the Quartzites, Schists and Conglomerates of Sauk Co., Wis., Am. Jour. Sci., Vol. III, Art. xv, p. 93. The same in Trans. of Wis. Acad. of Sci. Arts and Letters, Vol. II, pp. 107-119.

†Note on the Age of the Metamorphic Rocks of Portland, Dodge Co., Wis., Am. Jour. Sci., Vol. V, Art. xxxi, p. 282.

criticism, which even threatened the existence of the survey, later, a sullen acquiescence in the truth, and finally, an admiration for the correctness and the courage of the position taken and a diversion of enterprise from unprofitable into successful lines of exploitation. In the second and third years of the survey Professor Irving's field embraced the Paleozoic and Archæan strata of central Wisconsin. In the last years he returned to the Lake Superior field and laid the broader foundation upon which nearly all of his subsequent investigations were based. The results of his studies in this official relationship are recorded in the four volumes of the Reports of the Wisconsin Geological Survey (1873–1879). Meanwhile he had published several short articles in the American Journal of Science, the Transactions of the Wisconsin Academy, and elsewhere. Among these the more important are the "Age of the Copper-Bearing Rocks of Lake Superior and the Westward Continuation of the Lake Superior Synclinal." * "Some New Points in the Elementary Stratification of the Primordial and Cambrian Rocks of South Central Wisconsin."† "The Stratigraphy of the Huronian Series of Northern Wisconsin, and on the Equivalency of the Huronian of the Marquette and Penokee Districts." ‡

In 1880 Professor Irving began those investigations upon the geology of the Lake Superior region for the United States government which continued until the time of his death. The first of these consisted of a comprehensive study of the copper-bearing series, the results of which he gathered into a monograph which perhaps stands as the best single expression of his work. § This was the first approach to a unified and systematic discussion of this great formation occupying a tract of 40,000 square miles and embracing portions of Michigan, Wisconsin, Minnesota and Canada. Whatever differences of opinion may continue to exist concerning the interpretation of the debated phenomena, this must ever be recognized as a monument of industrious and able investigation and of candid and careful induction. Following these studies upon the copper-bearing series, Professor Irving took up in a correspondingly comprehensive manner, the investigation of the iron-bearing formations of the Lake Superior region and their correlation with each other and with the original Huronian of Canada. Upon this work he was engaged at the time of his death. He had in preparation and nearing completion a monograph upon the Penokee-Gogebic range and had well in hand a large amount of material relating to the Marquette, Menominee and Vermilion Lake series, as well as the original Huronian and Animike groups. His loss at this fruitful stage of his work, incal-

* Am. Jour. Sci., Vol. VIII, Art. vii, p. 46, 1874.

† Am. Jour. Sci., Vol. IX, Art. vii, p 440, 1875.

‡ Am. Jour. Sci., Vol. XVII, Art. xlix, p. 393, 1879.

§ "Copper-Bearing Rocks of Lake Superior." Monograph V., U. S. Geol. Survey, 1883.

culable as it is, might have been still greater but for the fact that all his material passed into the hands of his co-laborer, Professor Van Hise, who is intimately familiar with his unwritten as well as written views.

Some of Doctor Irving's leading conclusions from his later studies were set forth in his presidential address before the Wisconsin Academy of Sciences, Arts and Letters, entitled "Divisibility of the Aarchæan in the Northwest,"* and more especially in the following very notable papers: "Preliminary Paper on an Investigation of the Archæan Formations of the Northwestern States,"† "On the Classification of the Early Cambrian and Pre-Cambrian Formations: A Brief Discussion of Principles; Illustrated by examples drawn mainly from the Lake Superior Region,"‡ "Origin of Ferruginous Schists and Iron Ores of the Lake Superior Region,"‖ "Is there a Huronian Group?"¶ and the introduction to Bulletin Number 62 of the U. S. Geological Survey, "On the Greenstones of the Menominee and Marquette Regions," by Dr. G. H. Williams.

During these later years in which he was chiefly engaged upon monographic studies, he published numerous special papers, among which the more important were, "On the Nature of the Induration of the St. Peter's and Potsdam Sandstones, and of certain Archæan Quartzites in Wisconsin,"* "Paramorphic Origin of the Hornblende of the Northwestern States,"† "On Secondary Enlargements of Mineral Fragments in Certain Rocks"‡ (jointly with Professor C. R. Van Hise), and "The Junction Between the Eastern Sandstone and the Keweenawan Series on Keweenaw Point"§ (jointly with President Chamberlin).

Professor Irving's greatest contributions to science lay in the department of structural geology and genetic petrography. His investigations upon the great copper and iron-bearing series and the adjacent formations of the Lake Superior region, constitute a contribution of the first order. The deep sympathy of the present writer with Professor Irving's views on questions that have been subjects of divergence of opinion should perhaps restrain him from a full expression of his appreciation of the profound value of this work, lest a color of personal partiality be thrown over this sketch, but it is not too much to assert that supporter and opponent alike recognize the ability which has characterized these investigations, and the high order of value which must attach to them whatever interpretations may finally prevail.

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* Am. Jour. Sci., Vol. XXIX, pp. 237-249, 1885.

† U. S. Geol. Survey, Fifth Annual Report, pp. 181-241, 1885.

‡ U. S. Geol. Survey, Seventh Annual Report, 1886.

‖ Am. Jour. Sci., Vol. XXXII, p. 255, 1886.

¶ Am. Jour. Sci., Vol. XXXIV, pp. 204-249, 1887.

* Am. Jour. Sci., Vol. XXV, p. 401, 1883.

† Am. Jour. Sci., Vol. XXVI, p. 321, 1883.

‡ U. S. Geol. Survey, Bulletin No. 8.

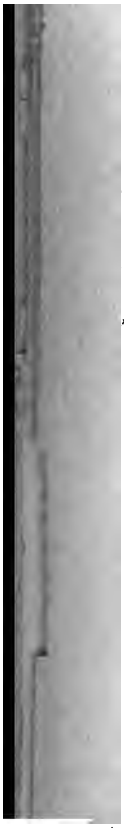
§ U. S. Geol. Survey, Bulletin No. 23.

In the line of petrographic genesis Professor Irving made two very notable contributions, first, the demonstration of the prevalence and importance of the secondary growth of certain fragmental constituents of clastic rocks and the crystallographic co-ordination of the additions with the nuclear particles. The existence of such a second growth in quartz grains was an earlier discovery of others but was hit upon by him independently. Jointly with his co-laborer, Professor Van Hise, he demonstrated a similar second growth of hornblende and other minerals and showed that such rebuilding was a prevalent process, constituting an important element in those changes heretofore designated metamorphic, thereby contributing an important factor in the elucidation of that mysterious process.

Perhaps the most important single determination by Professor Irving, and one of his latest, was the demonstration of the origin of the iron ores of the Lake Superior region. By a series of admirable investigations he traced step by step the transformation of the ores from original earthy carbonates of iron to their present forms, and made it altogether clear that they were primarily deposited as sediments in a manner closely similar to that of the iron ores of the Coal Measures. This discovery has given added significance to the association of these ores with carbonaceous shales, and has led to the recognition of the iron-bearing series as marking in some sense a pre-Cambrian carboniferous period.

The characteristics of Professor Irving as a scientific investigator and writer are too well known to the readers of this magazine to need analysis here. Personally, to those who came within the circle of his intimate acquaintance, he possessed rare charms of character. Sincere, frank, conscientious in the highest degree, he was a warm and true friend. Possessed of a rollicking brusque humor, his intercourse was marked by a freshness that was a source of constant enjoyment and attraction to his intimate associates. No phrase better expresses it than picturesqueness. Modest and retiring, the number of his close friends was not large but their attachment to him was strong. The full strength of these attachments has only been realized in their breaking.

He leaves a wife, a daughter and two sons. The artistic skill of Mrs. Irving appears in some of the sketches and particularly in many of the microscopic illustrations of her husband's works.



William F. Allen

WILLIAM FRANCIS ALLEN.

Late President of the Wisconsin Academy of Sciences, Arts and Letters.

BY JAMES D. BUTLER.

William Francis Allen was born September 5, 1830, and died December 9, 1889. His birth was in Northborough, a Massachusetts village, thirty-five miles from Boston; his death was in Madison. He graduated at Harvard University in 1851. His preparation for college was made at home in a school taught by his father, also a Harvard graduate, and a Unitarian pastor. For three years he gave instruction at New York city in a private family, and then in 1854 went abroad. He was for one year a student in the universities of Berlin and Göttingen. The following winter he spent in Rome, and the spring in Greece, returning to America in June, 1856. During the next seven years he was one of the principals of a classical school near Boston, at West Newton. Late in 1863, accompanied by his wife, married the year before, he went to South Carolina in the employ of the Freedman's Aid Association. After a half year of pioneer work in the education of negroes he came north, but very soon repaired to Arkansas as an agent of the Sanitary commission. This service was over early in 1865, and in the spring he returned to South Carolina, where he served till the close of the school year as a superintendent in Charleston. The next two years he taught, first in Antioch college, Ohio, and then at a military academy in New Jersey. His first wife died in 1865, and after three years he re-married.

Professor Allen was a religious man. He was the true founder of the Unitarian church in Madison. His life was a sermon of admonition and a hymn of praise. The training of his children, a daughter by the first marriage and three sons by the second, was a rare specimen of personal assiduity. His nature was so far from doing harms that he suspected none, and his faith in the doctrine of depravity may hence not have been orthodox. Notwithstanding, no more stinging censure smote Fisk and Tweed than fell from his lips.

His coming to Wisconsin was in 1867. In that year he accepted a call to the state university. His chair was at first called that of Ancient Languages and History, afterwards Latin and History, and for the last four years of his life History alone. In this Northwest he found the niche he was ordained to fill — for his teachings here his whole past life, studies at home and abroad, early training and varied school experi-

ences — proved an admirable preparation. How well he paid for more than a score of years the educational debt due to his profession it is needless to say. Witnesses abound on every side. They agree that he gave much information, but that in a way which inspired more than it informed. It was a favorite maxim with Prof. Allen that "moral education cannot be absent from any living system, that the only foundation of thoroughness in study is that virtue which embraces a larger share of human duties within its definition than any other — faithfulness." Exemplifying in himself the virtue he praised, he became an inspiration to many a student — filling him with a life-long delight in whatsoever things are true, honest, just, pure, lovely, virtuous and praiseworthy. Seeing him always an eager learner, his pupils became themselves the more eager to learn.

While faithful to all details of his instructional routine, Prof. Allen was a voluminous author. The bibliography of his writings, in his Memorial volume, fills thirty pages and comprises more than nine hundred articles. We do not wonder that the number is multitudinous, for many of the articles were brief, so much as at their diversified nature; titles are arranged under thirty specific heads, but some of them find their proper place only under yet another division styled Miscellaneous. Before we run our eyes over a tithe of the topics we feel that the author, who never wrote on a subject he had not investigated, was a multifarious scholar — a rare survival of what former generations called a polymathist. We are surprised that he, a recluse scholar, touched society at so many points. He treated of slave songs and the negro dialect, and of Latin grammar as well — now of Aristophanes and then of Uncle Remus — here of the snake dance in Arizona, and anon of a day with a Roman gentleman. He drew each change of many-colored life.

After all, our feeling is that Prof. Allen was first, last and chiefly an *historian*. A great majority of his papers, whether in periodicals, or the Madison Literary Club or in our Academy, were historical. If he wrote upon Shakespeare his themes were the historical plays. If his theme was Novels, it was historical fiction. His twenty lectures in Johns Hopkins University were historic. His editions of classics were mainly historical authors. Whatever the subject that came before him his view of it was historic. Every fact in his mind, if past, had made history; if present, was making history, and if future, was about to make history. Thus, through its relations, and thus only had any fact value for him. All were but parts of a stupendous whole.

From Prof. Allen's early sojourn in Rome as well as the nature of his academic and university teaching, Roman history became predominant in his thoughts, studies and writings. A hundred of his published articles on as many aspects of this vast department each shed some side light upon it. His editions of Cæsar and Tacitus, with notes upon

them, his classes in Sallust and Livy equipped him fully for writing with classic taste and terseness his own *Short History of the Roman People*, the crowning key-stone in the arch of his authorship — in penning the last line of which he ceased at once to work and live. Nay, rather, he still lives, for we are instinctively prompted to apply to him the touching words which he taught, edited, and loved so well: *Quicquid ex Agricola amavimus, quicquid mirati sumus, manet, mansurumque est in animis hominum.*

LUCIUS HERITAGE.

By HENRY DOTY MAXSON.

Lucius Heritage, son of Isaac C. and Margaret S. Heritage, was born Dec. 21, 1848, in Walworth, Wisconsin. In childhood his family removed to Milton, where he spent a large portion of his life. The death of his mother in 1864, led to a suspension of his studies and a temporary abandonment of his purpose to prepare himself for a profession. He accordingly became apprenticed to learn the wagon-maker's trade, and spent three years in this employment. His native taste for the things of the intellect led him, however, to embrace an opportunity to resume his studies, and he entered Milton College in 1869. Completing the Teacher's Course in that institution in 1872, he taught Latin for a short time in the St. Paul High School, and then returned to Milton to receive his diploma from the Classical Course, in 1875. In the fall of that year he became first assistant of Mr. Albert Markman, in the Milwaukee Academy, where he remained one year. It was my fortune after an interval of several years to succeed him in this position, and I found his reputation for character and scholarship still very vivid in the traditions of the school. He was pretty uniformly Mr. Markham's standard of comparison in speaking of the qualifications of a teacher. "As good a man as Heritage," was the highest compliment. In the fall of 1876 he sailed for Germany, where he spent a little over two years as a student in Göttingen, Halle and Leipsic. In the year after his return he was married to Miss Ruth G. Maxson, who survives him, with one son, their only child, born in 1885. It was during his temporary residence in Milton in 1879, that I first knew him. Our acquaintances are usually many; but the circle of friends who really enter the current of our life and make vital contributions to our character and thought, must always be small. It was my fortune from this time until his death, to number Prof. Heritage among these companions of the soul. In 1879 he was appointed Latin tutor in the University of Wisconsin. Prof. W. F. Allen, who, but for his untimely death, would have prepared a worthier biography than I am able to furnish, wrote soon after the death of Mr. Heritage that when he became a candidate for the instructorship in Latin, the University faculty were already predisposed in his favor on

account of the way in which he acquitted himself at an inter-state oratorical contest held in Madison some years before. "I remember nothing about the contestants or their subjects," says Prof. Allen, "except that the delegate from Milton College attracted our attention by his intellectual countenance and fine bearing." In 1882, he was elected Assistant Professor of Latin, and four years later was placed in full charge of the department. In 1883–4 he spent another year in Germany, for the purpose of pursuing some special studies. Throughout his life he was a hard worker at whatever he undertook. Never robust, he undoubtedly overtaxed his strength by intense application to his studies. For several years, though he himself displayed great confidence and courage, his immediate friends had been solicitous about his health; and when a threatened attack of pneumonia prostrated him in November, 1888, they feared that the end was not far off. He rallied, however, and for a short time resumed his work in the University, but was soon compelled to relinquish it, and started on a Southern trip in the hope of regaining his health. The effort was fruitless. He died in Redlands, California, May 14, 1889.

Prof. Heritage wrote very little for publication. His most important literary work was an edition of the Dialogues of Tacitus, which, at the time of his death, he had been for some years engaged in preparing.

It seldom happens that the *nil nisi verum* of the biographer becomes more nearly one with the *nil nisi bonum* of the eulogist than in the case of Mr. Heritage. Of an exceptionally keen and accurate mind, he was no less distinguished for the integrity of his character.

His work as a pupil and a teacher I know only at second hand. Of the latter Prof. Allen wrote: "Under his charge the Latin department has advanced steadily in thoroughness and breadth of training. As every year I have taken some of the higher classes in Latin, I have noticed a marked improvement from year to year in the quality of the scholarship, especially in the capacity of ready and correct translation. His power as a teacher was very great. He won the affection and confidence of his classes in the highest degree, and was as distinguished for firmness and strictness as for courtesy and fairness."

While capable of making a thoroughly creditable appearance in public, and always holding the attention of his hearers by his clearness in both thought and expression, he did not seek publicity. He was essentially a man of the study. The energy, which with many gifted people largely spends itself in more ostentatious ways, with him was rather employed in enlarging and refining his personal culture. And thus the informal contacts of intimate friendship became a source of keen delight. It was in this phase of his life that I knew him best. Conversation with him was always enriching. He approached a question not in the role of a debater, but of an inquirer. As far as the interests of truth are con-

cerned, debate is for those directly engaged in it worse than profitless, and it was repugnant to his temper. He was naturally restrained from taking the attitude of the advocate both by the judicialness of his mind and the candor of his character; and this disposition was powerfully reenforced by a discriminating intellect which refused to ignore identities or confuse distinctions. Add the command of a copious and precise vocabulary, and his equipment for enjoyable and instructive conversation was complete. It was almost a luxury to have him occasionally hesitate for a word. It gave one a moment to enjoy in anticipation the right word which was sure to come.

While by nature a man of the study, he by no means lacked interest in matters of public concern, and the interest was of a decidedly practical rather than of a merely academic character. Politics he greatly enjoyed, not at all as a trade, nor yet merely as a science, but more still as a field for effort in the line of promoting, or trying to promote, the common good. While he could never become a partisan, he was always anxious to actively identify himself with any organized effort to reform or purify our public life. The temperance problem and other social questions of importance in our day provoked earnest study, and when the line of action seemed clear, enthusiastic devotion. If he ever seemed to any one lacking in public participation in reformatory work, that fact must be set down to the impartiality of his mind, which insisted on seeing both sides of the shield; and that impartiality was greatly strengthened by an alert and delicate sense of humor- a quality of great service, not only in giving sparkle to speech, but also in restraining from absurdity. *In medio tutissimus ibis* was not with him the maxim of a calculating prudence. It rather represented the native temper of the man.

Of those deeper and more difficult themes which we call religious, we spoke frequently and freely. Mr. Heritage shrank from no light which the most thorough-going rationalism could shed on the problems of life. But through all this unrestrained communion of thought and inquiry, I never found his faith to falter in the underlying sanity of things, the eternal purpose which runs through all, and gives to human effort and character an immortal meaning. That purpose was most beautifully displayed in his life. We may well believe that, though not fully revealed to our eyes, that purpose has with no less beauty, been working itself out in his death.

H. D. MAXSON.

By PROF. J. W. STEARNS.

Rev. Henry Doty Maxson, vice-president of the Wisconsin Academy of Sciences, died suddenly at Eau Claire, Nov. 23, 1891. His connection with the Academy had not been long, but the transparent sincerity of the man and his complete devotion to the highest aims, had made a strong impression upon its members. Mr. Maxson was born in De Ruyter, New York, of Seventh Day Baptist family, and the wish of his parents, and his own early choice, destined him for the ministry in that denomination. Accordingly, he was in due time sent to the denominational college, at Alfred, N. Y., to commence his preparation. But before the end of his first year a great change had gradually taken place in his convictions; and he acted upon it with the frankness which always characterized him, by renouncing his cherished plans and returning to his home. I have heard him relate with much emotion the struggle it cost him to take this step, because of the pain which he knew it would cause his mother. It seemed to separate him from his parents, and to cut off for the present the hope of a college education, of which he was very desirous. Fortunately these results which he dreaded did not follow, and in due time he graduated, in 1877, from Amherst college. He took the lead of his class in college. He was not only at the head of it in scholarship, but also in character, a marked man to whom his classmates looked with affectionate esteem and almost with reverence. He came to Wisconsin as a teacher, and was employed first at Milton college, then at Markham's Academy, in Milwaukee, and afterward for nearly five years as Institute conductor for the State Normal School at Whitewater. This service brought him into connection with a large body of young people upon whom his influence was strong and inspiring. His genial manners, and his kindly interest in them and their pursuits made warm personal friends of his pupils. He stood before them a refined gentleman, of quick sympathies, thorough scholarship, and lofty aims, and they were broadened and uplifted by the intercourse with him. In the spring of 1888 he became pastor of the Unitarian church at Menomonie. Here he accomplished remarkable results in a very short time. The magnetism of the man was quickly felt, and drew

about him a strong following; and Bible classes, a kindergarten, a gymnasium, a literary society, a public library, arose and flourished under his inspiration. Mr. Maxson was an untiring worker for the broadening of human life and the refining of human nature. Although a close student himself, there was nothing of the recluse about him. On the contrary, he adapted himself with a sure insight to men of the most diverse types, and enjoyed deeply the opportunities of service to others which his position offered him. Thus in a brief life-time he was enabled to accomplish a notable work. Members of this society are familiar with his characteristics as a public speaker. His direct and truth-loving nature shone out in his discourse. You felt that a strong, sincere, cultured man was talking to you, and talking directly to the point, with a true insight and a large charity. He captivated you with the many-sidedness of his thought and the abundance of the resources from which it was illustrated and enforced. Those who had but a slight acquaintance with him felt the charm of his character, while those who enjoyed his intimacy found in him the best inspirations of a noble manhood.

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APPENDIX.

APPENDIX.

List of Societies, Institutions, etc., with which the Wisconsin Academy Exchanges Publications.

An * indicates that the society has been recently placed on list.

Argentine Republic—

Buenos Ayres. Oficina Meteorologica Argentina.

Cordoba. Academia Nacional de Ciencias en Cordoba.

Australia—

Sydney. (New South Wales.) Department of Mines.

Austria—

Brieg. (Silesia.) Naturforschende Gesellschaft.

Graz. (Styria.) Naturwissenschaftliche Verein für Steiermark.

Görlitz. (Silesia.) Naturforschende Gesellschaft.

Prag. (Bohemia.) Die königl. böhmische Gesellschaft der Wissenschaften.

Vienna. K. k. Akademie der Wissenschaften.

Zoologisch-Botanische Gesellschaft.

K. Akademie d. Wissenschaften.

K. k. Naturhistorisches Hofmuseum.

*K. k. Geologische Reichsanstalt.

Belgium—

Brussels. Société Royale Malacologique.

Liege. Société Royale des Sciences

Mons. Société des Sciences des Arts, et des Letters du Hainaut.

Brazil—

Rio Janeiro. Museu Nacional do Rio de Janeiro.

Instituto Historico e Geographico Brazileiro.

Canada—

Halifax. (Nova Scotia.) Nova Scotia Institute of Natural Sciences.

Hamilton. Hamilton Association.

Montreal. Natural History Society. (The Canadian Record of Science.)

Ottawa. Ottawa Normal School. "The Ottawa Naturalist."

Toronto. The Canadian Institute.

Chili—

Santiago. Deutsche Wissenschaftliche Verein.

China—Continued.
Observatorio Astronómico.
Oficina Central Meteorolojica de Chile.

Denmark —
Copenhagen. Kongelige Danske Videnskabernes Selskabs.

England —
London. Bernard Quaritch, 15 Piccadilly W., London, England.
British Museum.
The Royal Society.
Manchester. Manchester Literary and Philosophical Society.
Newcastle-upon-Tyne. North of England Institute of Mining and Mechanical Engineers.

Finland —
Helsingfors. Sociéte des Sciences de Finlande.
Finska Vetenskaps-Societetens.
Observatoire Magnétique et Météorologique.
Finska Vetenskabs-Societeten.

France —
Amiens. Société Linnéenne du Nord de la France.
Bordeaux. Académie Imperiale des Sciences, Belles Lettres et Arts.
Caen. L'Académie Nationale des Sciences, Arts et Belles-Lettres.
Dijon. Academie des Sciences, Arts et Belles Lettres.

France—Continued.
Le Mans. Société d'Agricult Sciences et Arts de la Sart
Lyon. Académie des Scien Belles Lettres et Arts.
Montpellier. Académie des S ences et Lettres.
Paris. Annuaire Geologique U versel (M. M. Carez et D villé, 15 Rue de Tournon).
Rouen. Société des Amis Sciences Naturelles.

Germany —
Bamberg. Naturforschende G sellschaft.
Berlin. *Deutsche geologisc Gesellschaft.
Kaiserliche Gesundheitsamte
Zeitschrift der Gesammt Naturwissenschaften.
Bonn. Naturhistorische Vere der Preussischen Rheinlan u. Westfalens.
Bremen. Naturwissenschaftlic Verein.
Braunschweig. Verein für Natu wissenschaft.
Brünn. Naturforschende Verei
Cassel. *Verein für Naturkund *Realschule.
Danzig. Naturforschende Gesel schaft.
Dresden. Die Naturwissenschaf liche Gesellschaft Isis.
Elberfeld. Naturwissenschaf liche Verein in Elberfeld.
Emden. (Friesland.) Naturfo schende Gesellschaft.
Frankfurt a.M. Physikalisc Verein.

Germany—Continued.

Freiburg. Naturforschende Gesellschaft.

Geissen. Oberhessische Gesellschaft.

Göttingen. Kgl. Gesellschaft der Wissenschaften.

Halle. (Prussia.) Zeitschrift für Naturwissenschaften. (Dr. O. Luedecke.)

Kaiserliche Leopoldino-Carolinische deutsche Akademie der Naturforscher.

Heidelberg. Naturhistorisch-Medizinsche Verein.

Jena. * University of Jena.

Medicinisch-Naturwissenschaftliche Gesellschaft.

Kiel. University of Kiel.

Königsberg. * University of Königsberg.

Leipzig. (Saxony.) Verein für Erdkunde.

Magdeburg. * Naturwissenschaftliche Verein zu Magdeburg.

Mannheim. Verein für Naturkunde.

Metz. L'Academie de Metz.

Munich. K. b. Akademie der Wissenschaften.

Königliche Sternwarte.

Nassau. Nassauische Verein.

Nürnberg. Naturhistorische Gesellschaft.

Regensburg. (Bavaria.) Naturwissenschaftliche Verein zu Regensburg.

Historische Verein von Oberpfalz und Regensburg.

Strassburg. * Kaiserliche Universitäts- u. Landes-Bibliothek.

Wiesbaden. Nassauische Verein für Naturkunde.

Holland —

Amsterdam. Koninklijke Akademie van Wetenschappen.

's-Gravenhage. Nederlandsche Maatschappij ter Bevordering van Nijverheid.

Haarlem. Musée Teyler.

Société Hollandaise des Sciences à Haarlem.

Rotterdam. Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte.

Utrecht. Provinciaal Utrechtsch Genootschap van Kunsten Wetenschappen.

Koninklijk Nederlandsch Meteorologisch Institut.

Hungary —

Budapest. Bureau of Statistics of the Capital City Budapest.

Ireland —

Dublin. Royal Irish Academy.

Royal Dublin Society.

Italy —

Bologna. Instituto di Bologna.

Catania. Accademia Gicenia di Scienze Naturali in Catania

Florence. R. Institute di Studi Superiori Practici e di Perfezronamento.

Biblioteca Nazionale Centrale di Firenze.

Milan. Reale Instituto Lombardo di Scienze e Lettere.

Modena. Societa dei Naturalisti.

Regia Accademia di Scienze Lettere ed Arti.

Italy—Continued.

Naples. L'Anomalo (Doctor Angelo Zuccarelli, Via Salvator Rosa No. 38).

Società Italiana delle Scienze.

*Società di Naturalisti in Napoli.

Palermo. (Sicily) Reale Accademia di Scienze, Lettere e Belle Arti di Palermo.

Pisa. Società Toscana di Scienzi Naturali.

Rome. Ministero della Pubblica Istruzione.

Comitato Geologico d'Italia.

Java—

Batavia. Königliche Verein fur Naturkunde (Koninklijke Natuurkundige Vereinigung).

Mexico—

Mexico. Sociedad de Geografia Y Estadistica de la Republica Mexicana.

Museo Nacional.

Sociedad Mexicana de Historia Natural.

Sociedad Cientifica "Antonio Alzate."

Tacubaya. Observatorio Astronómico Nacional de Tacubaya.

Norway

Bergen. Bergen Museum.

Christiana. Norwegian Meteorological Institute.

Norske Gradmaalingskommission.

Videnskabs Selskabet i Christiania.

University of Christiania.

Portugal—

Lisbon. Academia Real das Sciencias de Lisbon.

Russia—

Kharkow. Société des Naturalistes à l'Université Imperiale de Kharkou.

Moscow. Société Impériale des Naturalistes de Moscou.

Meteorologisches Observatorium der Landwirthschaftlichen Akademie.

Odessa. *Club Alpin de Crimée (M. le prof. Kamienski, Sec'y. Odessa, Russia.)

St. Petersburg. Royal Free Economical Society of St. Petersburg.

Comité Géologique.

Acti Horti Petropolitani.

Royal Academy of Sciences.

Physikalisches Central-Observatorium.

Scotland—

Edinburgh. Royal Society of Edinburgh.

Spain—

Barcelona.* Real Academia de Ciencias Y Artes de Barcelona.

Madrid. Real Academia de la Historia.

Sweden—

Lund. University of Lund.

Stockholm. Kongliga Svenska Vetenskaps Akademiens.

Kongl. Vitterhets Historie och Antigvitets Akademiens Manadsblad.

Sweden—Continued.

Upsala. University of Upsala. Royal Society of Science.

Switzerland—

Basel. Naturforschende Gesellschaft.

Berne. Schweizerische Naturforschende Gesellschaft.

Frauenfeld. Thurgauische Naturforschende Gesellschaft.

Freibourg. Société Fribourgeoise des Sciences Naturelles.

Lausanne. Société Vaudoise des Sciences Naturelles.

Neuchatel. Société des Sciences Naturelles.

St. Gallen. St. Gallische Natur wissenschaftliche Gesellschaft.

Zürich. Naturforschende Gesellschaft.

Schweitzerische botanische Gesellschaft.

United States—

ARKANSAS:

Little Rock. * Geological Survey of Arkansas.

CALIFORNIA:

Berkeley. Agricultural Experiment Station of University of California.

Sacramento. California State Mining Bureau. Wm. Irelan, Jr., State Mineralogist.

San Diego. "The West American Scientist."

San Francisco. California Academy of Sciences.

San José. Lick Observatory.

United States—Continued.

COLORADO:

Colorado Springs. *Colorado College Scientific Society.

Denver. The Colorado Scientific Society.

Golden. State School of Mines.

DISTRICT OF COLUMBIA:

Washington. U. S. Naval Observatory.

U. S. Geological Survey. J. W. Powell, Director.

Library of War Department.

*National Geographic Society.

Smithsonian Institution.

Bureau of Education.

The American Monthly Microscopical Journal.

Weather Bureau, Dep't of Agriculture.

U. S. National Museum.

ILLINOIS:

Avon. The American Antiquarian and Oriental Journal, edited by Stephen D. Peet.

Champaign. Illinois State Laboratory of Natural History.

Springfield. *Geological Survey of Illinois.

INDIANA:

Brookville. *Indiana Academy of Science.

Indianapolis. *Geological Survey of Indiana.

IOWA:

Des Moines. Iowa Academy of Sciences.

KANSAS:

Topeka. The Kansas Academy of Sciences.

United States—Continued.

MARYLAND:

Baltimore. Johns Hopkins University.

MASSACHUSETTS:

Boston. Boston Society of Natural History.

*Massachusetts Institute of Technology.

American Academy of Arts and Sciences.

Cambridge. (Harvard Univ.) Museum of Comparative Zoölogy.

*Harvard University Library.

Salem. The American Association for the Advancement of Science.

Worcester. *American Antiquarian Society.

MICHIGAN:

Lansing. (Geological Survey of Michigan.

MINNESOTA:

Minneapolis. Geological Survey of Minnesota.

Minneapolis. Minnesota Academy of Natural Sciences.

MISSOURI:

Jefferson City. *Geological Survey of Missouri.

St. Louis. Missouri Botanical Garden.

The Academy of Sciences of St. Louis.

Kansas City. "Kansas City Review of Science and Industry."

NEBRASKA:

Lincoln. University of Nebraska.

United States—Continued

NEW JERSEY:

Trenton. The Trento History Society.

Princeton. *Museum gy and Archæology ton College.

NEW YORK:

Albany. New York seum of Natural New York State Lil University of the New York.

New York. Torrey Club.

*The Auk: A Quart nal of Ornitholog

American Museum History. (Centra

New York Microsc ciety.

*American Geogra ciety.

*The Technical Ind

Linnæan Society.

NORTH CAROLINA:

Chapel Hill. *Geolo vey of North Car

The Elisha Mitchell Society.

OHIO:

Cincinnati. Cincinna of Natural History.

Cleveland. Clevela emy of Natural Sci

Columbus. Ohio Ar Experiment Stati Geological Survey

Granville. *Journal parative Neurolo Herrick, Editor.

United States—Continued.

OHIO:

Granville. *Bulletin of the Scientific Laboratories of Denison University. (W. G. Tight, M. S., Editor.)

PENNSYLVANIA:

Harrisburg. Second Geological Survey of Pennsylvania.

Philadelphia. Academy of Natural Sciences.

* The American Naturalist.

Zoological Society of Philadelphia.

State College. (Center County.) The Pennsylvania State College Agricultural Experiment Station.

United States—Continued.

TEXAS:

Austin. * Geological Survey of Texas.

WEST VIRGINIA:

* Morgantown. West Virginia University.

WISCONSIN:

Madison. Agricultural Experiment Station of University of Wisconsin.

State Historical Society.

University of Wisconsin.

Washburn Observatory of University of Wisconsin.

Milwaukee. Naturhistorische Verein von Wisconsin.

The following Colleges and Incorporated Academies of the state are entitled to receive the Transactions of the Academy:

Northwestern University, Watertown.
Milwaukee Academy, Milwaukee.
University of Wisconsin, Madison.
Ecclesiastical College of St. Lawrence, Mt. Calvary, Fond du Lac County.
Carroll College, Waukesha.
Pio Nono College, St. Francis, Milwaukee County.
Sacred Heart College, Watertown.
Lawrence University, Appleton.
Beloit College, Beloit.
Yale College, Galesville.
Concordia College, Milwaukee.
Ripon College, Ripon.
German English Academy, Milwaukee.
Nashota House, Nashota.

The Public Libraries of the following places in the state are entitled to receive the Transactions of the Academy:

Ashland,
Beaver Dam,
Eau Claire,
Fond du Lac,
Green Bay,
Janesville,
La Crosse,
Madison,
Manitowoc,
Marinette,
Menominee,
Merrill,
Milwaukee,
Neenah,
Sparta,
Superior,
Tomahawk,
Waupun.

CHARTER.

AN ACT TO INCORPORATE THE "WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS."

The people of the State of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. Lucius Fairchild, Nelson Dewey, John W. Hoyt, Increase A. Lapham, Alexander Mitchell, Wm. Pitt Lynde, Joseph Hobbins, E. B. Wolcott, Solon Marks, R. Z. Mason, G. M. Steele, T. C. Chamberlin, James H. Eaton, A. L. Chapin, Samuel Fallows, Charles Preuser, Wm. E. Smith, J. C. Foye, Wm. Dudley, P. Englemann, A. S. McDill, John Murrish, Geo. P. Delaplaine, J. G. Knapp, S. V. Shipman, Edward D. Holton, P. R. Hoy, Thaddeus C. Pound, Charles E. Bross, Lyman C. Draper, John A. Byrne, O. R. Smith, J. M. Bingham, Henry Bætz, Ll. Breese, Thos. S. Allen, S. S. Barlow, Chas. R. Gill, C. L. Harris, George Reed, J. G. Thorp, William Wilson, Samuel D. Hastings and D. A. Baldwin, at present being members and officers of an association known as "The Wisconsin Academy of Sciences, Arts and Letters," located at the city of Madison, together with their future associates and successors forever, are hereby created a body corporate by the name and style of the "Wisconsin Academy of Sciences, Arts and Letters," and by that name shall have perpetual succession; shall be capable in law of contracting and being contracted with, of suing and being sued, of pleading and being impleaded in all courts of competent jurisdiction; and may do and perform such acts as are usually performed by like corporate bodies.

SECTION 2. The general objects of the Academy shall be to encourage investigation and disseminate correct views in the various departments of science, literature and the arts. Among the specific objects of the Academy shall be embraced the following:

1. Researches and investigations in the various departments of the material, metaphysical, ethical, ethnological and social sciences.

2. A progressive and thorough scientific survey of the state, with a view of determining its mineral, agricultural and other resources.

3. The advancement of the useful arts, through the applications of science, and by the encouragement of original invention.

4. The encouragement of the fine arts, by means of honors and prizes awarded to artists for original works of superior merit.

5. The formation of scientific, economical and art museums.

6. The encouragement of philological and historical resear collection and preservation of historic records, and the format general library.

7. The diffusion of knowledge by the publication of original co tions to science, literature and the arts.

SECTION 3. Said Academy may have a common seal and alter tl at pleasure; may ordain and enforce such constitution, regulatic by-laws as may be necessary, and alter the same at pleasure; may and hold real and personal property, and may use and dispose same at pleasure; *provided*, that it shall not divert any donation quest from the uses and objects proposed by the donor, and that the property acquired by it shall, in any manner, be alienated oth in the way of an exchange of duplicate specimens, books, and other with similar institutions and in the manner specified in the next of this act, without the consent of the legislature.

SECTION 4. It shall be the duty of the said Academy, so far same may be done without detriment to its own collections, to f at the discretion of its officers, duplicate typical specimens of in natural history to the University of Wisconsin, and to the schools and colleges of the state.

SECTION 5. It shall be the duty of said Academy to keep a record of all its financial and other transactions, and at the close c fiscal year, the president thereof shall report the same to the go of the state, to be by him laid before the legislature.

SECTION 6. The constitution and by-laws of said Academy force shall govern the corporation hereby created, until regularly or repealed; and the present officers of said Academy shall be of the corporation hereby created, until their respective terms of shall regularly expire, or until their places shall be otherwise vaca

SECTION 7. Any existing society or institution having like embraced by said Academy, may be constituted a department the be otherwise connected therewith, on terms mutually satisfactory governing bodies of the said Academy and such other society stitution.

SECTION 8. For the proper preservation of such scientific spec books and other collections as said Academy may make, the go shall prepare such apartment or apartments in the capital as ma occupied without inconvenience to the state.

SECTION 9. This act shall take effect and be in force from an its passage.

Approved March 16, 1870.

CONSTITUTION.

NAME AND LOCATION.

SECTION 1. This association shall be called "The Wisconsin Academy of Sciences, Arts and Letters," and shall be located at the city of Madison.

GENERAL OBJECTS.

SECTION 2. The general object of the Academy shall be to encourage investigations and disseminate correct views in the various departments of Science, Literature and the Arts.

DEPARTMENTS.

SECTION 3. The Academy shall comprise separate Departments, not less than three in number, of which those first organized shall be:

1st. *The Department of Speculative Philosophy* —

Embracing:

Metaphysics;
Ethics.

2d. *The Department of the Social and Political Sciences* —

Embracing:

Jurisprudence;
Political Science;
Education;
Public Health;
Social Economy.

3d. *The Department of the Natural Sciences* —

Embracing:

The Mathematical and Physical Sciences;
Natural History;
The Anthropological and Ethnological Sciences.

4th. *The Department of the Arts* —

Embracing:

The Practical Arts;
The Fine Arts.

5th. The Department of Letters—

Embracing:

Language;
Literature;
Criticism;
History.

SECTION 4. Any branch of these Departments may be constituted a section; and any section or group of sections may be expanded into a full department, whenever such expansion shall be deemed important.

SECTION 5. Any existing society or institution may be constituted a Department, on terms approved by two-thirds of the voting members present at two successive regular meetings of the Academy.

SPECIAL OBJECTS OF THE DEPARTMENTS.

SECTION 6. The specific objects of the Department of Science shall be:

1. General Scientific Research.

2. A progressive and thorough Scientific Survey of the State, under the direction of the Officers of the Academy.

3. The formation of a Scientific Museum.

4. The Diffusion of Knowledge by the publication of Original Contributions to Science.

The objects of the Department of Arts shall be:

1. The Advancement of the Useful Arts, through the Applications of Science and the Encouragement of Original Invention.

2. The Encouragement of the Fine Arts and the Improvement of the Public Taste, by means of Honors and Prizes awarded to Works of Superior merit, by Original Contributions to Art, and the formation of an Art Museum.

The object of the Department of Letters, shall be:

1. The Encouragement of Philological and Historical Research.
2. The Improvement of the English Language.
3. The Collection and Preservation of Historic Records.
4. The Formation of a General Library.

MEMBERSHIP.

SECTION 7. The Academy shall embrace four classes of governing members who shall be admitted by vote of the Academy, in the manner to be prescribed in the By-Laws:

1st. Annual Members, who shall pay an initiation fee of five dollars, and thereafter an annual fee of two dollars.

2d. Members for Life, who shall pay a fee of one hundred dollars.

3d. Patrons, whose contributions shall not be less than five hundred dollars.

4th. Founders, whose contributions shall not be less than the sum of one thousand dollars.

Provision may also be made for the election of Honorary and Corresponding Members, as may be directed in the By-Laws of the Academy.

MANAGEMENT.

SECTION 8. The management of the Academy shall be entrusted to a General Council; the immediate control of each Department to a Department Council. The General Council shall consist of the officers of the Academy, the officers of the Departments, the Governor and Lieutenant Governor, the Superintendent of Public Instruction, and the President of the State University, the President and Secretary of the State Agricultural Society, the President and Secretary of the State Historical Society, Counselors *ex officios*, and three Counselors to be elected for each Department. The Department Councils shall consist of the President and Secretary of the Academy, the officers of the Department, and three Counselors to be chosen by the Department.

OFFICERS.

SECTION 9. The officers of the Academy shall be: a President, who shall be *ex-officio* President of each of the Departments; one Vice-President for each Department; a General Secretary; a General Treasurer; a Director of the Museum, and a General Librarian.

SECTION 10. The officers of each Department shall be a Vice-President, who shall be *ex-officio* a Vice-president of the Academy; a Secretary and such other officers as may be created by the General Council.

SECTION 11. The officers of the Academy and the Departments shall hold their respective offices for the term of three years and until their successors are elected.

SECTION 12. The first election of officers under this Constitution shall be by its members at the first meeting of the Academy.

SECTION 13. The duties of the officers and the mode of their election, after the first election, as likewise the frequency, place and date of all meetings, shall be prescribed by the By-Laws of the Academy, which shall be framed and adopted by the General Council.

SECTION 14. No compensation shall be paid to any person whatever, and no expenses incurred for any person or object whatever, except under the authority of the Council.

RELATING TO AMENDMENTS.

SECTION 15. Every proposition to alter or amend this constitutic shall be submitted in writing at a regular meeting; and if two-thirds c the members present at the next regular meeting vote in the affirmativ it shall be adopted.

AMENDMENTS TO THE CONSTITUTION.

Amendment to Section 3: "The Department of the Arts shall b hereafter divided into the Department of the Mechanic Arts and th Department of the Fine Arts." Passed February 14, 1876.

BY-LAWS.

ELECTION OF MEMBERS.

1. Candidates for membership must be proposed in writing, by a member, to the General Council and referred to a Committee on Nominations, which Committee may nominate to the Academy. A majority vote shall elect. Honorary and corresponding members must be persons who have rendered some marked service to Science, the Arts, or Letters, or to the Academy.

ELECTION OF OFFICERS.

2. All officers of the Academy shall be elected by ballot.

MEETINGS.

2. The regular meetings of the Academy shall be held as follows:

On the 2d Tuesday in February, at the seat of the Academy; and in July, at such place and exact date as shall be fixed by the Council; the first named to be the Annual Meeting. The hour shall be designated by the Secretary in the notice of the meeting. At any regular meeting, ten members shall constitute a quorum for the transaction of business. Special meetings may be called by the President at his discretion, or by request of any five members of the General Council.

DUTIES OF OFFICERS.

□ 4. The President, Vice-President, Secretaries, Treasurer, Director of the Museum and Librarian shall perform the duties usually appertaining to their respective offices, or such as shall be required by the Council. The Treasurer shall give such security as shall be satisfactory to the Council, and pay such rate of interest on funds held by him as the Council shall determine. Five members of the General Council shall constitute a quorum.

COMMITTEES.

5. There shall be the following Standing Committees, to consist of three members each, when no other number is specified:

On Nominations.
On Papers presented to the Academy.
On Finance.
On the Museum.

On the Library.

On the Scientific Survey of the State: which Committee shall consist of the Governor, the President of the State University, and the President of this Academy.

On Publication; which Committee shall consist of the President of the Academy, the Vice-Presidents, and the General Secretary.

MUSEUM AND LIBRARY.

6. No books shall be taken from the Library, or works or specimens from the Museum, except by authority of the General Council; but it shall be the duty of said Council to provide for the distribution to the State University and to the Colleges and Public Schools of the State, of such duplicates of typical specimens in Natural History as the Academy may be able to supply without detriment to its collections.

ORDER OF BUSINESS.

7. The order of business at all regular meetings of the Academy or of any Department, shall be as follows:

Reading of minutes of previous meeting.
Reception of donations.
Reports of officers and committees.
Deferred business.
New business.
Reading and discussion of papers.

SUSPENSION AND AMENDMENT OF BY-LAWS.

8. The By-Laws may be suspended by a unanimous vote, and in case of the order of business a majority may suspend. They may be amended in the same manner as is provided for in the Constitution, for its amendment.

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